OMEGA®
ENGINEERING, INC.

OWNERS MANUAL

MODEL 400B

OMEGA'S DIGITAL TEMPERATURE INDICATORS

WARRANTY

OMEGA warrants this unit to be free of defects in materials and workmanship and to give satisfactory service for a period of 1 year. If the unit should malfunction, it must be returned to the factory for evaluation. Our Customer Service Department will issue an Authorized Return Number immediately upon phone or written request. Upon examination by **OMEGA**, if the unit is found to be defective, it will be repaired or replaced at no charge. However, this WARRANTY is VOID if the unit shows evidence of having been opened or tampered with, shows evidence of being damaged as a result of excessive current, heat, moisture, vibration or misuse. **OMEGA** assumes no consequential warranties or obligations beyond repair or replacement of the above unit.

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MANUAL 400-4203-04B

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SECTION 1

DESCRIPTION

1.1 GENERAL DESCRIPTION

This manual contains installation, operation, and service in information for Series 400 digital indicators. These solid state instruments digitally display a number of thermocouple, RTD, linear voltage sources, and current transmitter outputs in engineering units. All instruments feature a microvolt A/D converter, digital linearization, dual slope integration, and a large easy-to-read LED display.

The displays are in-line, uniplanar, LED type with 0.8'' high numerals, easily read through the front plexiglas panel. A single dash (-) displayed at the left of the readout indicates a negative polarity. Positive readings are inferred (no sign displayed). All dashes (----) across the display indicate an overload, overrange, or open thermocouple condition. Zeros to the left of the decimal point or most significant digit are suppressed.

All Series 400 digital indicators may be readily converted to accept all ranges shown in 1.1.1 by installing the appropriate PMOS LSI chip and analog programing module. Three LSI chips, K7500, K7501, and K7502 handle all ranges listed, but an individual analog programming module must be used for each range specified. Units (except those using Thermistor range) are easily converted from °F to °C readout (and vice versa) by a switch located behind the front panel.

The instruments are ordered with either high or standard sensitivity (resolution). Instruments with thermocouple input ranges provide a resolution of 1 degree (°F and °C) with 0.1 degree resolution available for applications where higher sensitivity is required. Transmitter input ranges are available with 0.1% or 0.01% resolution. Resolution for linear voltage ranges are shown in 1.1.1.

All units operate from a 100, 120, 220, or 240 VAC 48-400 Hz power source. Units powered by the optional battery power pack operate on an internal 10 VDC source. Power consumption is about 1.5 watts under typical operation, or about 4 watts with all segments lit. A power connector and ground screw for shields are located at the rear of the instrument.

1.1.1 INPUT RANGES AND RESOLUTION

Installing the correct Range Module (Col. 1) and LSI chip (Col. 3) converts model ranges as shown in the following chart.

RANGE DESIGNATOR	RANGE	IC TYPE	INPUT SENSOR TYPE	RESOLUTION MODEL 40X	RESOLUTION MODEL 41X
J (NBS)	-328 to +1712°F -200 to +933°C	K7500	Iron Constantan*	1°	0.1°
2J (J NBS)	-328 to +1712°F -200 to +933°C	K7502	Iron-Constantan*	1°	0.1°
K (NBS)	-208 to +2552°F -133 to +1400°C	K7500 K7501 K7502	Chromel-Alumel*	1°	0.1°
T (NBS)	-328 to +752°F -200 to +400°C	K7500	Copper-Constantan*	1°	0.1°
2T (T NBS)	-328 to +752°F -200 to +400°C	K7502	Copper-Constantan*	1°	0.1°
R (NBS)	+32 to +3252°F 0 to +1788°C	K7500	Platinum-Platinum* 13% Rhodium	1°	0.1°
S (NBS)	+32 to +3252°F 0 to +1788°C	K7500	Platinum-Platinum* 10% Rhodium	1°	0.1°
B (NBS)	912 to +3392°F 489 to +1866°C	K7500	Plat. 30% Rhod./* Plat. 6% Rhod.	1°	0.1°
FC (DIN)	-327.9 to +1651.9°F -199.9 to +899.9°C	K7501	Iron-Constantan*	1°	0.1°
CC (DIN)	-327.9 to +1111.9°F -199.9 to +599.9°C	K7501	Copper-Constantan*	1°	0.1°
E (NBS)	-327.9 to +1951.9°F -199.9 to +1066.6°C		Chromel-Constantan*	1°	0.1°
P3 & P4 (DIN)	-387.9 to +1631.9°F -233.3 to +888.8°C		3 or 4-wire RTD 0.00385 α	1°	0.1°
P5 & P6 (USA)	-387.9 to +1631.9°F -233.3 to +888.8°C		3 or 4-wire RTD 0.00392α	1°	0.1°
C3 & C4	-75.0 to +400°F -60.0 to +200.0°C		2 or 4-wire (CU4) 3-wire (CU3) RTD	1°	0.1°
TF TC	32.0 to 212.0°F 0.0 to 100.0°C		THERMISTOR	1°	0.1°
K1	-10 to +25 mV	K 7501	Linear Voltage	10μV	1μV
K2	-100 to +250 mV	or	Linear Voltage	100μV	10μV
K3	-1 to +2.5 V	K 7502	Linear Voltage	1 mV	100μV
K4	-10 to +25 V		Linear Voltage	10mV	1 mV
K5	+100 to +2500 digits (Models 400, 402); +1000 to 25000 digits (Models 410, 412)		Linear Voltage	0.001	0.0001
I1	0 to 100%		4 to 20 mA Current Transmitter	0.1%	0.01%
I2	0 to 100%		10 to 50 mA Current Transmitter	0.1%	0.01%
I_3	+100 to +2500 digits (Models 400, 402); +1000 to +25000 digits (Models 410, 412)		4 to 20 mA Current Transmitter	0.001	0.0001
1000 mV†	-0.5 V to +1 V	K7501	Linear Voltage	1mV	100μV

*Thermocouple Type Sensor

†Available in Models 408 and 418 only.

1.2 DESCRIPTION OF THE MODELS

The following table lists instruments by model, and shows the range and number of input points accepted by each.

MODEL →	400	402	403	405	406	407	408	409	410	412	415	418
NO. POINTS →	1	5	1	10	1	1	1	10	1	5	1	1
MULTIRANGE →	NO	NO	YES	NO	NO	NO	YES	NO	NO	NO	YES	YES
RANGE ↓												
J	X	X	X	X	X	X			X	X	X	
K	X	X	X	X	X	X	X		X	X	X	X
T	X	X	X	X	X	X			X	X	X	
R	X	X	X	X	X	X			X	X	X	
S	X	X	X	X	X	X			X	X	X	
B	X	X	X	X	X	X			X	X	X	
FC	X	X		X	X	X	X		X	X		X
CC	X	X		X	X	X	X		X	X		X
E	X	X		X	X	X	X		X	X		X
P3 P4 P5 P6	X				X		X[4]	X	X			X[4]
C3 & C4	X			X[2]	X			X	X			
TC &TF	X				X			X	X			
K1-K5	X	X		X	X	X[3]			X	X		
1000 mV[1]							X					X
I1 – I3	X				X				X			

Note 1: To use 1000 mV range on Models 408/418, °C/°F switch must be set to °C.

Note 2: Model 405 may be used with C4 when C4 is connected 2-wire.

Note 3: Model 407 can be used for K1 range only.

Note 4: P4 range only

1.2.1 Single Range Models

Models 400, 402, 410, and 412 are all single range indicators that can be adapted to accept any range (RTD, thermistor, and current ranges excepted on Models 402/412). Two of these single range models, Model 402 and Model 412, can accept five inputs within a chosen range. Inputs are selected for display by a row of

pushbuttons below the display. Model 400 and Model 402 are standard resolution instruments while Models 410 and 412 are high resolution instruments (refer to table in 1.1.1). A portable battery pack option is available for Models 400/410 indicators. Refer to 1.2.3.2. Model 400 and Model 410 can accommodate pcb (printed circuit board) options designed to extend the capability of the basic instrument. Refer to 1.2.3.3.

1.2.2 Multirange Models

Models 403, 408, 415, and 418 have pushbutton-selectable ranges. Models 403 and 408 have standard resolution while Models 415 and 418 have high resolution. Models 403 and 415 accept NBS type J, K, T, R, S, and B thermocouple inputs. Models 408 and 418 accept DIN type FeCon and CuCon thermocouple inputs, NBS type E and K thermocouple inputs, 4-wire PT RTD (alpha = .00385), and 1000 mV linear input.

1.2.3 Options

1.2.3.1 External Switching Stations, Models 405 and 409

The External Switching Stations provide input switching of ten points for use with a single range indicator. The External Switching Stations are housed in the same rugged case design as a basic indicator. Each may be rack-mounted beside another switcher or indicator. Pushbuttons are in two rows of five and are numbered 1-10, 11-20, etc. Each row is interlocked to prevent simultaneous input selection. Option 001A (refer to 1.2.3.3) may be used with one or more switchers, and blanks the display if simultaneous selections are made from two rows. Model 405 is used for thermocouple ranges, linear voltage ranges, the 1000 mV range, and 2-wire operation on the C4 range. Model 409 is used for all RTD and thermistor ranges.

1.2.3.2 Power Packs, Models 406 and 407

Models 406 and 407 are batterypack/chargers with low battery LED indicator. Model 407, in conjunction with its indicator, is also a precision calibrator.

The Power Pack is housed in a carrying case (see Figure 3-5 in Section 3). Interconnections between the Power Pack and indicator are made in the rear. Signal input connections to the Power Pack unit are made in front using 5-way binding posts. Model 406 may have either two or four input terminals, the latter for RTD and Thermistor ranges. Model 407 has two input terminals only and is used for thermocouple and K1 ranges only.

The Power Pack operates from AC or internal battery power. The battery pack is charged whenever the instrument operates from AC.

Model 407 has the additional capability to operate as a calibration voltage source for calibration of thermocouple instruments. The output is adjusted via the FINE and COARSE controls on the front panel. The FINE control incorporates a push-pull ON/OFF switch for the calibrator output. When ON, the calibrator output voltage is displayed on the indicator and available at the front terminals. After the COARSE adjustment is made, the FINE control is used which provides a vernier range of approximately + /-20 uV with 1 uV or 0.1° resolution. Output voltage is from -10 to + 100 millivolts.

1.2.3.3 Printed Circuit Board Options

The following printed circuit board (pcb) options are available for increased versatility of Series 400 indicators. Any one of these pcb options can be installed in Models 400/410 indicators. Additional pcb options can be accommodated by using the Model 411 option chassis. Any two options can be installed in the Model 411 option chassis for usage with any indicator model. Note however, that the option chassis must be located no further than 45.7 cm (18.00") from the indicator or another 411 option chassis. The Model 411 Option Chassis is provided with all necessary hardware, labels, and installation drawings.

Option 001A is used in conjunction with Models 405 or 409 switching stations to provide blanking of the display if simultaneous pushbutton selections are made from two rows.

Option 002A provides BCD output of the indicator display for external display or processing.

Options 003A/004A provides a single digital setpoint capability with manual or automatic reset, out-of-limit LED indication, and relay contact actuation. Option 004A provides an additional hysteresis "deadband" control for two position or on/off operation.

Option 005A provides an isolated analog output which is proportional to the indicator display. The output is ideal for use with strip chart recorders or other applications where an analog voltage input is required.

1.3 PHYSICAL DESCRIPTION

All Series 400 instrument cases are constructed of die cast aluminum covered with textured vinyl paint. Case dimensions are 72mm x 144mm x 173mm (2.84" x 5.67" x 6.82"). The case inserts into a panel cutout of 68mm x 138mm (2.68" x 5.44"). These dimensions are shown on the outline dimensional drawing found in Section 6. Net instrument weight is approximately 1.7 kg (2.5 lbs).

The portable Power Pack unit measures 144mm x 144mm x 200mm (5.67" x 5.67" x 7.78"); weight is 4.8 kg (10.5 lbs).

1.4 WARRANTY REPAIR

This unit is warranted to be free of defective materials or workmanship and to give satisfactory service for one year. Refer to the inside back cover of this manual for complete terms of the warranty. If the unit malfunctions, return it to the factory for evaluation. If evaluation shows the instrument to be defective under terms of the warranty, it will be repaired or replaced at no charge. Refer to 2.2 for instrument repacking and return instructions.

This WARRANTY is VOID if the unit shows evidence of having been opened or tampered with or shows evidence of damage due to excessive current or voltage, heat, moisture, vibration, or misuse.

In any event, no warranites or obligations beyond replacement or repair of the unit will be assumed.

1.5 SPECIFICATIONS

Ambient Operating Temperatures:
0 to 50°C; 32 to 122°F
Ambient Humidity:
0 to 70% at 0 to 50°C for rated accuracy.
Power:

100, 120, 220, or 240 VAC 48-400 Hz

Normal Mode Noise Rejection:
56 db at 50 Hz
60 db at 58 Hz and above
(3 pole, low-pass filter with 6 Hz poles; 1 pole on K3, K4)

Common Mode Noise Rejection:
110 db at 50 Hz; 120 db at 58 to 62 Hz (250Ω unbalance)
(up to 230 VDC or VAC RMS)

RFI Suppression:
Power line and sensor RFI filtering included

Reliability:
30,000 hours MTBF, calculated and demonstrated

Input:
Bipolar potentiometric operational amplifier with an input impedance at room temperature of:

22 megohms for thermocouple ranges
71 kΩ for RTD and thermistor ranges.
12.5 ohms for I1 transducer ranges (4-20 mA)
5 ohms for I2 transducer ranges (10-50 mA)
6 ohms for I_3 transducer ranges (4-20 mA)
1,000 megohms for K1, K2, K3 ranges
10 megohms for K4 & K5 range

Open T/C or Break Detection:
On TC ranges, 30 nanoamp, negative DC. Allows parallel connection of most other controllers with negligible interaction. RTD ranges inherently upscale break detect.

Source Resistance Effect:
TC ranges: 1.5 μV offset/50Ω.
P4 & P6 range: 0.03° C/Ω offset in +I and −V leads; 0.001° C/Ω in +V and −I leads.
P3 & P5 range: add 2.5° C/Ω unbalance between +I, +V, and −V leads.
C4 range: 0.02° C/Ω offset in +I −V leads and 0.002° C/Ω in +V and −I leads.
C3 range: add 25.9° C/Ω unbalance between +I, +V and −V leads.

Overload Protection:
TC, linear voltage, RTD and TH ranges: 120vAC or DC continuous. 230vAC or DC for 5 minutes without damage.
I1 range: up to 80 mA
I2 range: up to 200 mA
I_3 range: up to 80 mA

Measurement Time:
0.3 second per reading at low magnitudes
Up to 1.5 seconds per integration

Battery type (Option 406):

10V, rechargeable, sealed module.

2-5 hours continuous operation per charge. Recharge time of 10-12 hours. Good for 500 cycles.

Linearization:

100% digital using segments as shown for range:

Range	Segments
J, K, R, S, B, PT-100	46
Fe Con, Cu Con	45
E	44
T	42

Segment sizes for Linearization:

Range	Segment (°F)
R, S	70°
B	80°
K	60°
J	60° > 32°F 20° < 32°F
T	30° > 32°F 20° < 32°F
RTD	30° < 32°F < 50°
Fe Con	20° < 32°F < 60°
Cu Con	40° < 32°F < 30°
E	30° < 32°F < 60°

Stability with temperature:

Cold junction: (TC ranges only)

0.025 degrees/degree from 10 to 40°C (50 to 104°F) for base metal types; 0.05 degrees/degree for noble metals

Instrument zero:

1 μV/°C for Models 400 and 402 except 2 μV/°C on I_3 and K5 range

0.5 μV/°C for Models 410 and 412 except 1.5 μV/°C on I_3 and K5 range

Instrument span:

0.01% RDG/°C for Models 400 and 402 except 0.02% RDG/°C on I_3 range
0.005% RDG/°C for Models 410 and 412 except 0.015% RDG/°C on I_3 range

Stability with time:

Instrument zero:

No measurable zero drift

Instrument span:

0.1% of RDG/yr for transmitter and voltage ranges; less than 1°/yr for TC, RTD, and TH ranges.

Repeatability:

±1 digit except on listed 410 , 412 , 415 ranges:
±2 μV on K1, CU and TH ranges,
±0.2° C or F on R, S, and B ranges,
±0.2° F below -200° F on T range.

PCB Option Specifications:

BCD Data Output (Option 002A):

Output Logic Level: positive true, 8-4-2-1 BCD digits, TTL/CMOS compatible
Fanout: two standard TTL inputs

Single Limit Digital Alarm/Setpoint (Options 003A/004A):

Setpoint Range: -3999. to +3999. (In Model 410, the setting represents the four most significant digits).
Deadband Range (004A): 0 to 9
Relays: Form C, 115 VAC, 1A
Reset: Manual or Automatic (switch selectable)
Resolution: +/- 1° C or F.

Analog Output (005A):

Output Accuracy: +/- 2 mV, +/- 0.25% of reading
Ouput: 1 mV/degree F or C (isolated)
Load Impedance: 5k ohm (minimum)

Accuracy

RANGE DESIGNATOR	TYPE OF INPUT	RANGE	ACCURACY (all ±) includes max linearization error	
			400/402 403/408	410/412 415/418
J 2J	Iron Constantan Thermocouple	328°F to + 1712°F 200°C to + 933°C	1° 1°	0.6°F 0.5°C
K	Chromel Alumel Thermocouple	208°F to + 2552°F 133°C to + 1400°C	1.5°C>0°C<1° 1°	1.2°C>0°C>0.8° 0.8°C>0°C>0.5°
T 2T	Copper Constantan Thermocouple	328°F to + 752°F 200°C to + 400°C	1° 1°	0.5° 0.5°C
R	Platinum Platinum 13% Rhodium Thermocouple	+ 32 to + 3252°F 0 to 1788°C	3°>350°F>1.5° 2°	3°<350°F<1.5° 2°<200°C<1 0.6° above 800°C
S	Platinum Platinum 10% Rhodium Thermocouple	+ 32 to 3252°F 0 to + 1788°C	3°>600°F>2° 2°	2°<600°F<1.5° 2°<315°C<1 0.5° above 800°C
B**	Plat 30% Rhod Plat 6% Rhod Thermocouple	+ 912 to + 3392°F + 489 to + 1856°C	4° 2.5°	2.5° 1°
FeCon	DIN Thermocouple Iron Constantan	200°C to + 900°C	1°	0.4°
CuCon	DIN Thermocouple Copper Constantan	200°C to + 600°C	1°	0.4°<0°C<0.2°
E	EINBS)Thermocouple Chromel Constantan	328°F to + 1952°F 200°C to + 1066°C	1° 1°	0.7° 0.4
P3 & P4 P5 & P6	PT 100 RTD	388 to + 1632°F 233 to + 888°C	1° 1°	0.7°<-328°<0.4° 0.3°< 200°>0.2°
C3 & C4	CU 10 RTD	75 to + 400°F 60 to + 200°C	1° 1°	1.0° 1.0°
TF & TC	YSI Thermistor Series 700	+ 32 to + 212°F 0 to + 100°C	0.4° 0.2°	0.40° 0.20°
I1*	4-20 mA Transducer Current Transmitter	0 to 100%	1 count	0.01% of reading + 1 count
I2*	10-50 mA Transducer Current Transmitter	0 to 100%	1 count	0.01% of reading + 1 count
I3	4-20 mA Transducer Current Transmitter	Span Digits Adj (20 mA 5V input) + 1000 to + 2500 400 and 412 Offset Digits Adj (4 mA/0V input) + 5 times span to max of 1000 - 2000 for 400 and 402 + 5 times span to max of 10000 - 20000 for 410 and 412	5 counts	50 counts
K5	0-5 Volt Range linear voltage			
K1*	25 Millivolt Range Linear Voltage	10 mV to + 25 mV	1 count	0.01% of reading + 2 counts
K2*	250 Millivolt Range Linear Voltage	100 mV to + 250 mV	1 count	0.01% of reading + 1 count
K3*	2.5 Volt Range Linear Voltage	1V to 2.5V	1 count	0.01% of reading + 1 count
K4*	25 Volt Range Linear Voltage	10V to 25V	1 count	0.01% of reading + 1 count

Resolution for Thermocouple and PT 100 models 400 401 403 408 1°
410 412 415/418 - 0.1°

*Special scaling available from 200 to 26,000 counts full scale on these ranges Consult factory

**Lookup table can be easily developed to use "B" range below 912°F (489°C) down to room temperature Formula in manual

SECTION 2

INSTALLATION

2.1 UNPACKING AND INSPECTION

The Series 400 indicators are rugged instruments, but they must be properly packed. Instruments are shipped in a custom-designed carton yet shipping damage may occur. When you receive your instrument, look for evidence of transit damage as it is unpacked. If damage is found, ask the carrier to prepare a Damage Inspection Report and notify our Customer Service Department immediately. If your instrument has arrived in good condition, perform the functional test described in 2.3 to verify proper operation.

2.2 REPACKING, RETURNING THE INSTRUMENT

If convenient, the original shipping container should be retained for returning instrument for repair or modification. Before returning any instrument, please contact our Customer Service Department, and they will issue an authorized return number and shipping instructions.

a. Select a strong cardboard box of sufficient size to allow an inch of packing material around all sides of the unit.
b. Ensure the printed circuit boards are secured and the front and rear panels are firmly in place.
c. Wrap the instrument in plastic or strong paper. Place it centrally in the shipping container, and pack polyfoam, bubblepack, or rubberized hair around all six sides of the instrument.
d. Tape the carton flaps securely and label the container "FRAGILE, DELICATE INSTRUMENT". Ship it freight prepaid. Never ship by U.S. mail.

2.3 INSTRUMENT CHECKOUT PROCEDURE

An instrument functional checkout may be made as follows:

a. Remove the rear cover.
b. For thermocouple and K1-K5 ranges short all input terminals with copper wire (NOTE 1). Connect RTD ranges per NOTE 2, and TH ranges per NOTE 3. Leave terminals open on I ranges.
c. Apply power to the instrument . The display should approximate the appropriate readout in the table below.

INPUT TYPE	SIGNAL INPUT TERMINALS	READOUT
Thermocouples (see note 1)	shorted	room temperature
RTD	(see note 2)	0°C or 32°F
K1, K2, K3, K4 ,K5	shorted	0 ± 10 μV
I1, I2	open	-25.00%
I_3	open	-0.25 Span + (Offset)
TC/TF Thermistor	(see note 3)	0°C/32°F

NOTE 1: For "B" thermocouple range, simulate the TC input with a millivolt calibrator. Example: a 4.833 mV input should produce a display of about 1832°F (1000°C).

NOTE 2: Connect +V and +I, and -V and -I. Connect a resistor equal to the RTD R_O between +V and -V.

NOTE 3: Connect two resistors, 25.425KΩ from +I to +V, 100K from +V to -I.

2.4 CONFIGURING THE INSTRUMENT, GENERAL

The instrument is configured at the factory for various power, range, and display requirements as stated on the initial order.
However, the instrument can easily be reconfigured to accomodate any future changes as required by the user.

The following paragraphs describe power voltage selection, range programming, and display programming (°C/°F and decimal point placement).

2.4.1 Selecting Power Voltage

The instrument is configured to operate from a 100, 120, 220, or 240 VAC 48-400 Hz power source as specified on the order.
To reconfigure the instrument for the desired voltage, cut etch(es) and install appropriate jumper(s) according to the printed circuit board (pcb) version being modified. See figure below.

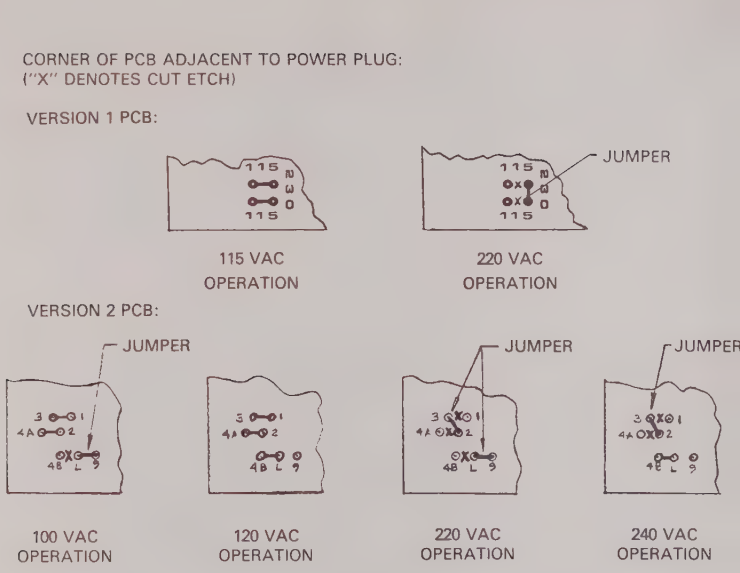


FIGURE 2-1. POWER VOLTAGE CONFIGURATION

2.4.2 Range Programming

In order for the instrument to operate on a specific range, it must have the proper combination of analog programming module and PMOS LSI chip. The table in paragraph 1.1.1. shows the correlation. For example, to operate in the "J" range, a "J" type module and a K7500 LSI chip must be installed. Installation of the module and chip is shown in Figure 2-2.

The beveled corner of the module (Pin 1) must be aligned correctly when installed (Pin 1 on module to Pin 1 on socket). When installing the PMOS LSI chip, the notched end of the chip points away from the zero and span pots. Exercise care

when installing and removing these components. For example, the best way to remove the LSI chip (to prevent lead damage) is to apply gentle upward pressure (alternating one end, then the other) with fingers or wide screwdriver.

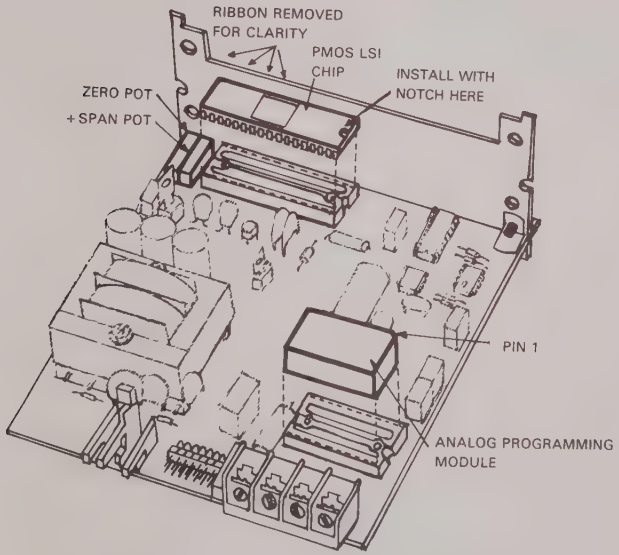


FIGURE 2-2. INSTALLING THE LSI CHIP AND ANALOG PROGRAMMING MODULE

2.4.3. °F/°C and Decimal Point Programming

A mini-DIP switch assembly configures the display for °F or °C range and decimal point placement. The switch assembly is located behind the plexiglas front panel and just below the display as shown in Figure 2-3. Figure 2-3 shows 5 seven segment LEDs used in high resolution instruments (Models 41X). For other instruments (Models 40X), the rightmost seven segment LED is not installed.

The leftmost switch, marked C/F, selects Celsius or Fahrenheit readout. For °C readout, slide the switch upwards. For °F readout, slide the switch downwards. If the instrument has a rocker type switch assembly, press the upper portion of the switch for °C readout or press the lower portion of the switch for °F readout. Both switch types may be actuated with a ball point pen or small screwdriver.

NOTE

For all "K", "I", and thermistor (TC/TF) ranges, set the C/F switch to F. Set the C/F switch to C for the 1000mV range on Models 408 or 418.

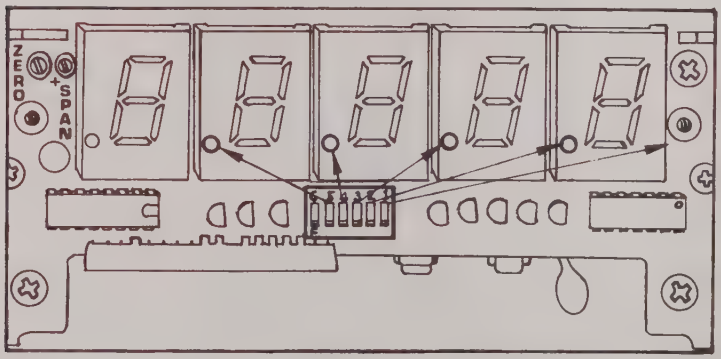


FIGURE 2-3. DISPLAY CONFIGURATION, °C/°F AND DECIMAL POINT

The remaining switches, marked 5, 4, 3, 2, 1, set the decimal point. To place the decimal point in the desired position (see Figure 2-4), slide the appropriate switch to the up position (ON) with the remaining switches in the down position (OFF). If the instrument has a rocker type switch assembly, press the upper portion of the switch to illuminate the appropriate decimal point. The remaining switches should be off (lower portion pressed). If no decimal point is desired, switch #1 must be set ON for Models 41X and switch #2 set ON for Models 40X (switch #1 not operable on Models 40X). The remaining decimal point select switches must be set OFF.

2.5 MOUNTING THE INSTRUMENT

2.5.1 Panel Mounting

Panel mounting hardware is supplied standard with the instrument. Install as shown in Figure 2-4. The instrument bezel butts against the front of the mounting panel; the mounting bracket fits over the instrument rear panel. The bracket screws force it against the rear of the mounting panel, locking the instrument in place. Panel cutout dimensions are 68mm x 138mm (2.68" x 5.44").

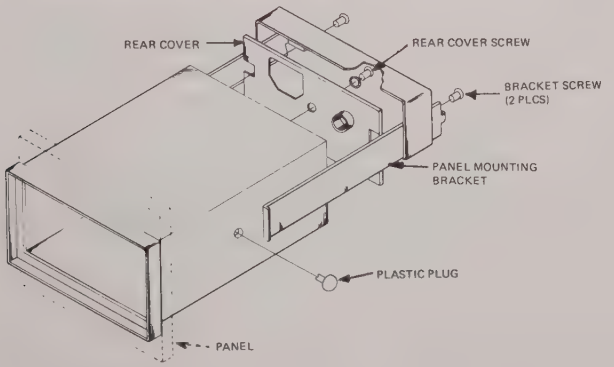


FIGURE 2-4. PANEL MOUNTING

2.5.2 Bench Mounting (Option 00W5)

Option 00W5 provides convenient bench-top use of the instrument. The bench mount features no-skid rubber feet and an adjustable pivot to change the vertical viewing angle. It is shown in Figure 2-5.

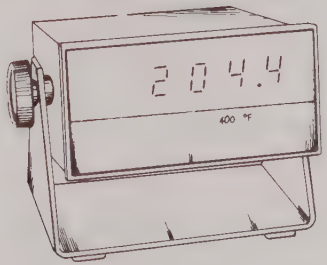


FIGURE 2-5. BENCH MOUNT

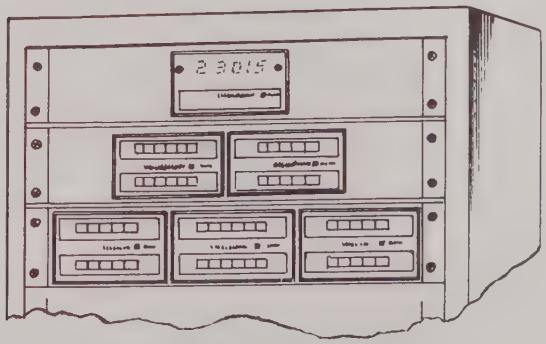


FIGURE 2-6. INSTRUMENTS IN RACK MOUNT ADAPTERS

2.5.3 Rack Mounting (Option 0W6—)

Rack mounting adapters 90mm x 483mm (3.5'' x 19'') are available with cutouts for one, two, or three instruments (Option 0W61, 0W62, or 0W63) which are installed with panel mounting hardware as described in 2.5.1. Rack mounted instruments are shown in Figure 2-6.

2.6 OPTION INSTALLATION

Various options are offered which may be installed by the factory or by the user. These include all PCB options and Power Pack units. The following paragraphs detail installation of these options.

2.6.1 Installing PCB Options in Models 400/410 Indicators

When a Model 400 or 410 indicator is ordered from the factory with a PCB option, the board is installed in the instrument before shipment. In the event a PCB option is ordered separately, this procedure is used to install the board in the instrument.

a. If instrument is installed, remove panel mounting bracket, then disconnect sensors, grounding wires, and power ground screw.

b. Remove the front plexiglas panel (two screws).

c. Remove two screws (front of instrument) which secure display board to chassis.

d. Slide board assembly outward from the front.

e. Turn board assembly over so that component side of main board is up.

f. Invert PCB option board and place over main board, component side to component side, except Option 002, which is installed with its component side facing away from the main board component side.

g. Attach PCB option board to display board with two screws and lockwashers included in kit as shown in Figure 2-7.

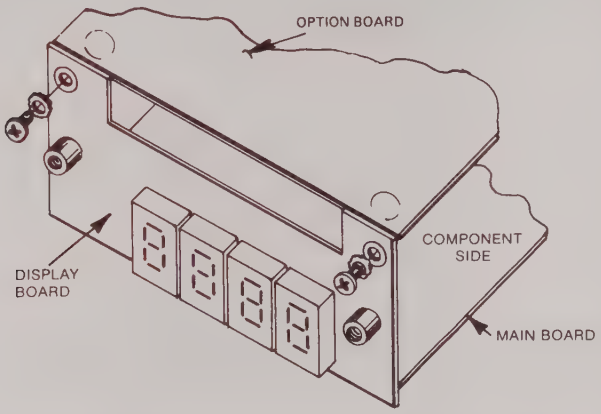


FIGURE 2-7. INSTALLING OPTION BOARD ON DISPLAY BOARD

h. Connect ribbon cable P1 on the option board to connector P2 on the main board. Cable must be inserted so that paint stripe on plug is visible. See Figure 2-8.

i. Slide board assemblies back into chassis, affix label (which identifies screw terminals on option board) to inside edge of case, and re-assemble instrument, reversing steps a, b, and c. For Options 002, 003A, 004A, and 005A only, do not re-install rear cover. Proceed to next step.

j. For options 003A, 004A, and 005A only, connect ground lead terminated in spade lug from the option board to chassis ground screw as shown in Figure 2-8, then re-install rear cover. For Option 002A, fasten bracket on circuit side of pcb to chassis cross bar using chassis ground screw on cross bar, then re-install rear cover.

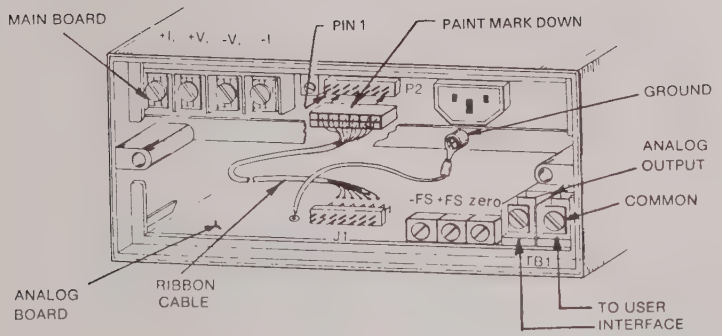


FIGURE 2-8. TYPICAL OPTION INSTALLATION, REAR VIEW OF INSTRUMENT

2.6.2 Installing PCB Options in Model 411 Option Chassis

The Model 411 Option Chassis accommodates any two PCB options for additional expansion capability of Series 400 indicators. As specified on the initial order, the front panel can either be blank or provided with one or two cutouts to expose thumbwheel switches and alarm LEDs for options 003A or 004A. Installation details differ depending on which combination of options are installed. Refer to the Model 411 installation drawings in Section 6.

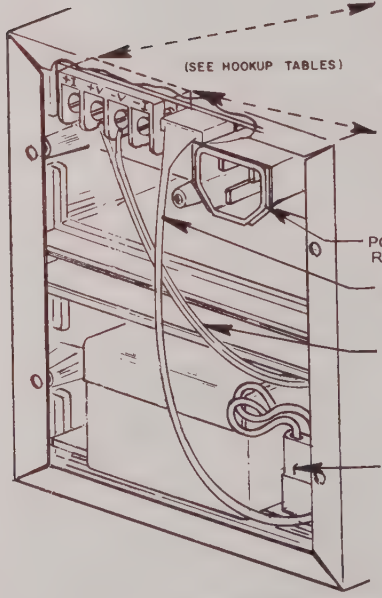
Option 002A, the BCD Data Output board, must be installed in the lower slot of the option chassis for clearance of the PCB edge connector. A special rear cover, p/n 411-2040-00, is used to accommodate Option 002A. Other options may be used in either slot of the option chassis.

Note that the Model 411 option chassis must be located no further than 45.7 cm (18.00 inches) from the indicator or another Model 411 option chassis.

2.6.3 Installing the Instrument in a Power Pack Case

When ordered together, the indicator and Power Pack are mated together at the factory. If shipped separately, assemble as follows:

a. Remove the indicator rear plate; it is no longer required.



MODEL 406 HOOKUP TABLE

RANGE TYPE	TERMINALS			
	+V	-V	+I	-I
TC RANGE	VARIES	RED	–	–
K1-K5	WHITE	RED	–	–
I1 – I3	–	–	WHITE/ BLACK	WHITE/ RED
RTD & TH	WHITE	RED	WHITE/ BLACK	WHITE/ RED

MODEL 407 HOOKUP TABLE

RANGE TYPE/ CALIBRATOR WIRE	TERMINALS	
	+V	-V
TC RANGE	VARIES	RED
K1 RANGE	WHITE	RED

FIGURE 2-9. INDICATOR INSTALLATION IN A POWER PACK CASE

b. Remove the rear cover of the Power Pack.

c. If there are plastic plugs in the sides of the indicator case, pry them out with a screwdriver; slide the indicator into the power pack upper section from the front.

d. Connect the battery I/O cable from the Power Pack board to P2 on the indicator as shown in Figure 2-9 (paint stripe visible on connector plug when connected).

e. Connect the front panel binding posts (from BEHIND the panel) to the rear input terminals of the indicator in parallel, using appropriate lengths of twisted pair wire (voltage, current, RTD, thermistor ranges) or thermocouple extension wire (thermocouple ranges). See Figure 2-9 for the correct polarity of various applications.

f. Plug the battery connector into the battery board as shown in Figure 2-9.

g. Install Power Pack rear cover.

h. Connect the AC power cord and verify that the LED display lights immediately. If it doesn't, disconnect the power cord and recheck all connections including the power voltage jumpers. Contact Customer Service immediately if the unit still isn't working.

2.7 INPUT/OUTPUT CONNECTIONS

2.7.1 Basic (Models 400/410) and Multirange Instruments

All signal input connections are made to the rear of the instrument using screw terminals. To gain access to the recessed terminal strip, the rear cover place must be removed. The four signal input terminals are located in the upper-left corner, and are labeled +I, +V, -V, and -I. See Figure 2-10.

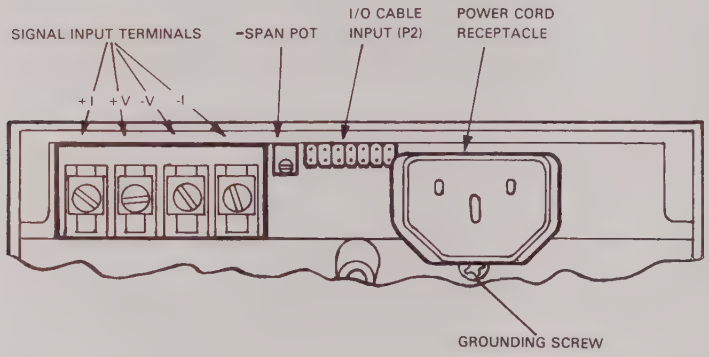


FIGURE 2-10. BASIC AND MULTIRANGE INSTRUMENT REAR VIEW

Connections for the various types of signal input wires is shown in Figure 2-11. The input wires must pass through the rear cover grommet. Recommended points for grounding are also shown. For better noise rejection, the sensor and shield (if used) should be grounded at the source or instrument. Never ground sensor or shield at both points. Current transmitter (I1-I3) input wires are not normally grounded. The ground point for the instrument is located on the horizontal cross bar (see Figure 2-10).

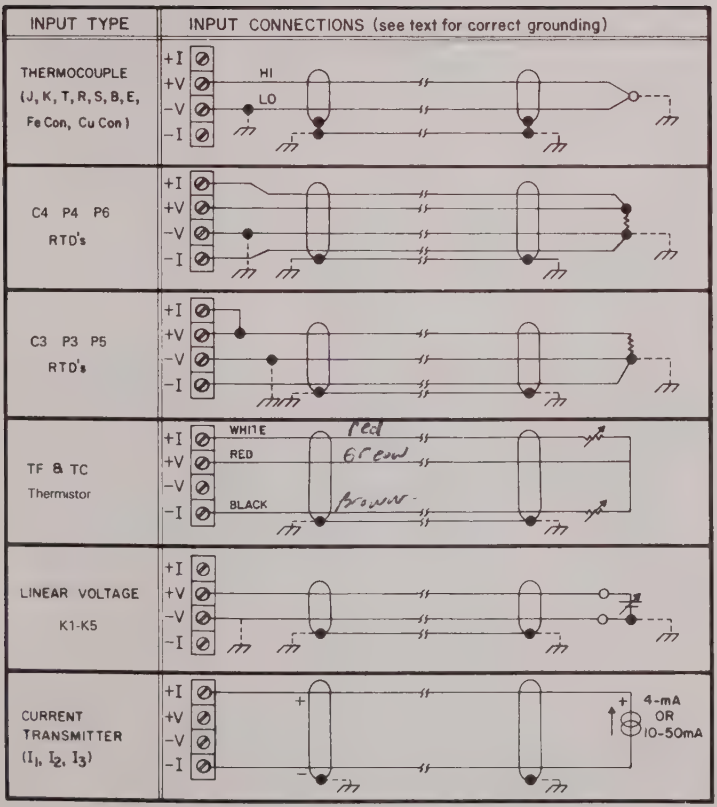


FIGURE 2-11. SIGNAL CONNECTION DIAGRAMS

2.7.2 Five Input Switching Units, Models 402/412

Figure 2-12 shows signal connections for Models 402/412. The same type of thermocouple wire as the signal inputs being switched is used to connect the common output from the switch board to the input terminals labeled + V and -V. Up to five pairs of signal input wires (+ and -) can be connected to the input terminal strip.

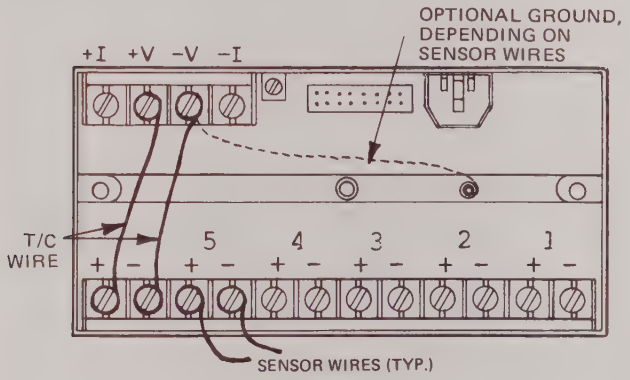


FIGURE 2-12. MODELS 402/412 REAR VIEW, SIGNAL CONNECTIONS

2.7.3 Power Pack Units, Models 406/407

The signal input connections for Model 406 and 407 Power Packs are made at the front of the instrument to binding posts. See Figure 3-5 in Section 3. Although the posts are arranged differently from the rear terminals, the connections are the same as shown on the connection diagrams of Figure 2-11. The posts are clearly marked + I, + V, − V, and − I as applicable to the type of input used.

Connections to the posts may be made in several ways. If the signal wire terminates with a standard banana plug, it may be inserted directly into the end of the binding post. By unscrewing the binding post cap, signal input wires up to 14 AWG may be terminated by wrapping around the post or by inserting the wire through the hole provided in the post. The cap should be tightened against the wire to make a secure connection.

2.7.4 External Switching Stations, Models 405/409, and Switch Error Board, Option 001A

The Model 405 External Switching Station accommodates thermocouple, linear voltage, and current inputs. Up to ten pairs of signal leads (+ and -) can be connected to the rear terminal strips of the Model 405 External Switching Stations. See Figure 2-13.

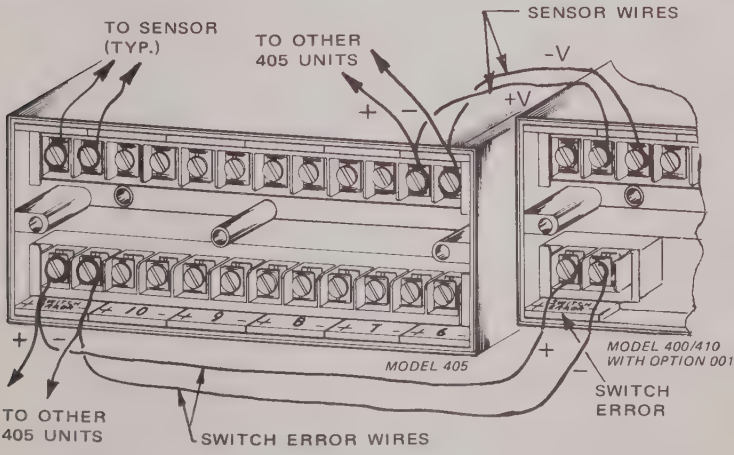


FIGURE 2-13. MODEL 405 REAR VIEW, SIGNAL CONNECTIONS

A pair of terminals (+ and −) on the upper right is the common output which is connected to the indicator's +V and −V input terminals. The common output can also be used as an input to another Model 405 unit. A pair of terminals (+ and −) on the lower left is the switch error output which is connected to the + and − input of the switch error board in the indicator or Model 411 option chassis.

The Model 409 External Switching Station accomodates up to ten sets of 3 or 4-wire RTD or themistor inputs (+ I, + V, -V, and -I). See Figure 2-14.

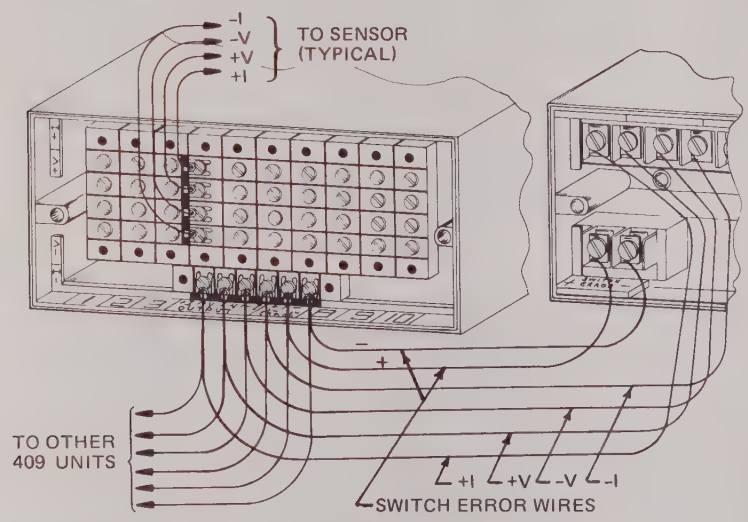


FIGURE 2-14. MODEL 409 REAR VIEW, SIGNAL CONNECTIONS

All connections are usually made to the Fanning strips supplied with the Model 409 unit. Signal leads are crimped and soldered to the Fanning strips and then installed on the appropriate terminals at the switching unit. Input terminals are arranged in ten vertical banks of four. Output terminals (common output + I, + V, -V, -I and switch error + and -) are placed horizontally directly below the input terminals. The common output can also be used as an input to another Model 409 unit. The switch error output (+ and -) is connected to the + and - input of the switch error board in the indicator or Model 411 option chassis.

2.7.5 BCD Data Output Board (Option 002A)

External connections to the BCD Data Output Board are made via the 30-pin mating connector provided with the option. Using the mating connector supplied, a cable is fabricated by the user as required. Cable connections are shown in Figure 2-15.

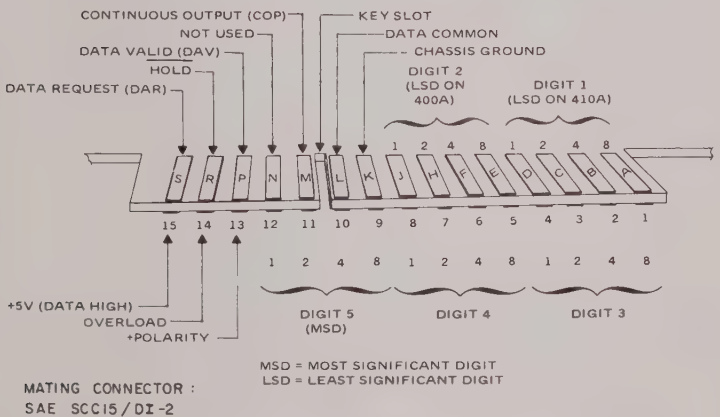

CONTINUOUS OUTPUT (COP)
NOT USED
DATA VALID (DAV)
HOLD
DATA REQUEST (DAR)
KEY SLOT
DATA COMMON
CHASSIS GROUND
DIGIT 2 (LSD ON 400A)
DIGIT 1 (LSD ON 410A)
1 2 4 8 1 2 4 8
S R P N M L K J H E W O C B A
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
1 2 4 8 1 2 4 8 1 2 4 8
+5V (DATA HIGH)
OVERLOAD
+POLARITY
DIGIT 5 (MSD)
DIGIT 4
DIGIT 3
MSD = MOST SIGNIFICANT DIGIT
LSD = LEAST SIGNIFICANT DIGIT
MATING CONNECTOR :
SAE SCC15/DI-2

FIGURE 2-15. DATA OUTPUT PIN ASSIGNMENTS (OPTION 002A)

All outputs are TTL compatible, and fanout is two standard TTL inputs. Input commands require only 250 μA sink current; therefore, they are both TTL and CMOS compatible. Data outputs are positive true, 8-4-2-1 BCD. Note that terminals A, B, C, and D are unused in applications using a standard resolution indicator.

Although the data output is fully isolated from the indicator's sensor input and power line connections, good wiring practices should be followed for cabling outputs. Both data common and chassis ground are provided for cable shielding. Also,

the command lines DAR and $\overline{\text{HOLD}}$ should not be too closely bundled to the data output lines in order to prevent possible crosstalk. Maximum recommended cable length is 7.62 meters (25 feet) to peripheral. Data output should also be kept away from sensor input wires to prevent possible crosstalk.

The + polarity line is independently "true" (high) for positive displays, and "false" (low) for negative displays.

Overload is "true" (high) for an overload (over scale or broken sensor) indication on the display (all dashes), and "false" (low) for normal in-range readings.

Data common is provided for logic low reference, as is the data outputs' +5V supply for logic high reference. Current capability of the +5V output is 500 μA maximum which allows up to 10 unused TTL inputs to be wired high externally.

Timing for the data valid is shown in Figure 2-16. The positive going edge of DAV should be used for triggering an external printer or other device. The DAV pulse is low for approximately 3.5 msec during the data update, and no BCD outputs should be taken during this period.

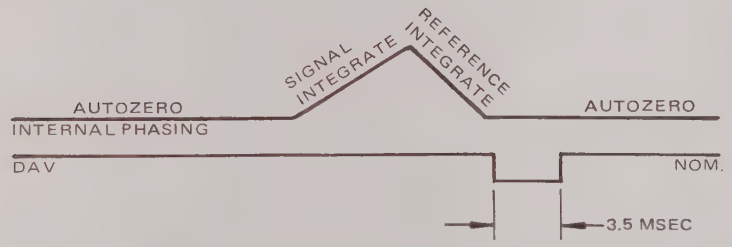


FIGURE 2-16. OPTION 002A, DATA OUTPUT TIMING DIAGRAM

If the DAR line is held high indefinitely, no further DAV transitions occur after the first. If continuous DAV updates are desired for each encoding (that is, for a DAV interrupt scheme), the continuous output (COP) may be wired or switched directly to the DAR command line. In this mode a DAV update occurs after every encoding.

Unless the command line $\overline{\text{HOLD}}$ is low (ground contact closure), the indicator takes continuous readings as in normal operation. When $\overline{\text{HOLD}}$ is taken low, the last readings are displayed indefinitely, and no new conversions are made. In this mode, DAV is high continuously. Displayed data is valid on the output lines, however, and could be utilized if desired.

The normal command for data output is the data request (DAR) line. If the unit is not in hold ($\overline{\text{HOLD}}$ = 1 or open), then a positive edge transition on DAR causes one subsequent DAV output pulse at the next completed encoding time. Each positive edge on DAR causes only one DAV update if the DAR pulse conforms to Figure 2-17.

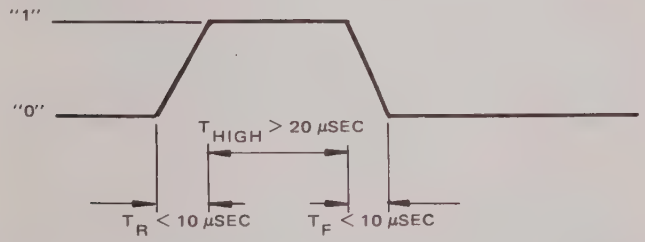


FIGURE 2-17. DAR COMMAND FORMAT

2.7.6 Alarm Setpoint Boards (Options 003A/004A)

External connections for alarm relay contacts and relay reset inputs for both Alarm Setpoint boards (Options 003A/004A) are made to terminal strip TB1 on the Alarm Setpoint board. See Figure 2-18. Relay contacts have a rating of 1 A @ 120 VAC and can be used to operate various annunciator devices upon alarm. A normally open, momentary contact switch is connected by the user as required for manual reset of the alarm relay.

WARNING: Lethal AC power voltages may be present on barrier terminals. Exercise caution when working in this area.

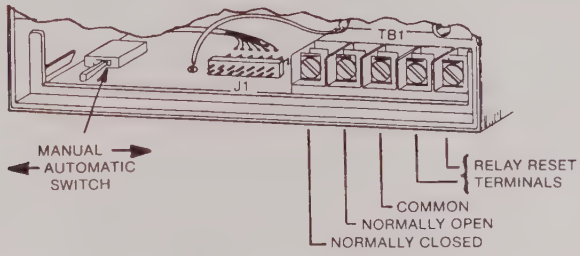


FIGURE 2-18. TB1 ON ALARM SETPOINT BOARDS (OPTIONS 003A/004A)

2.7.7 Analog Output Board (Option 005A)

A pair of screw terminals on terminal strip TB1 provides the output connection from the Analog Output board (Option 005A). See Figure 2-19. Use a twisted pair cable for connecting the analog output to the external device input.

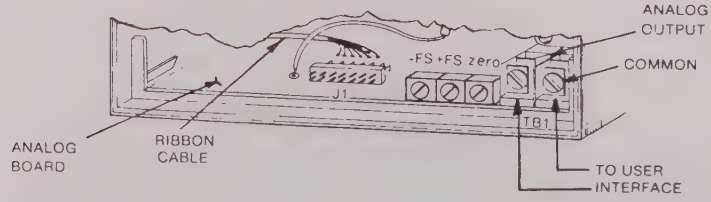


FIGURE 2-19. ANALOG OUTPUT TERMINALS (TB1)

SECTION 3

OPERATION

3.1 APPLYING POWER TO THE INSTRUMENT

Power is applied to the instrument as long as the instrument is plugged into an active AC power source. To remove power, unplug the power cord from the instrument or AC outlet.

To eliminate shock hazard and/or possible instrument damage, always remove the power cord from either the instrument or power source before a range (programming module) change is made (single range models) and/or a sensor rewired (all models).

3.2 USING BASIC UNITS (MODELS 400/410)

The Models 400/410 indicators are single range indicators with a single input. Once the instrument is configured for the desired range (refer to 2.4) measurements can be made by connecting the appropriate sensor to the rear input terminals (refer to 2.7.1). Observe operating guidelines per 3.1 above.

3.3 USING THE MULTIRANGE UNITS (MODELS 403/415/408/418)

Multirange units accommodate six ranges which are selectable by a row of pushbuttons below the display. Each pushbutton is labeled with a particular range. To use a particular range, connect the sensor to the instrument (power OFF), press the appropriate pushbutton, and apply instrument power. The pushbuttons are interlocked so that only one pushbutton is selected at one time.

When using a multirange unit with the Model 406 or 407 Power Pack, the front panel binding posts of the power pack unit may be used for TC ranges if the interconnect between indicator and power pack binding posts is of the appropriate type

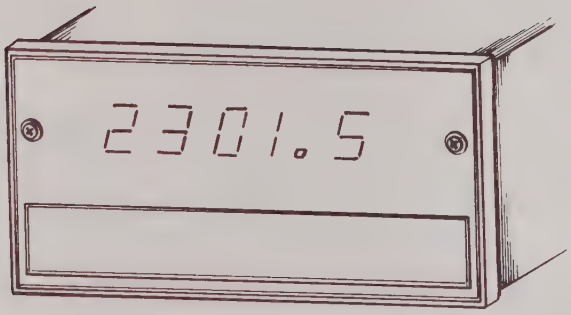


FIGURE 3-1. FRONT PANEL, BASIC INDICATOR (MODEL 410 SHOWN)

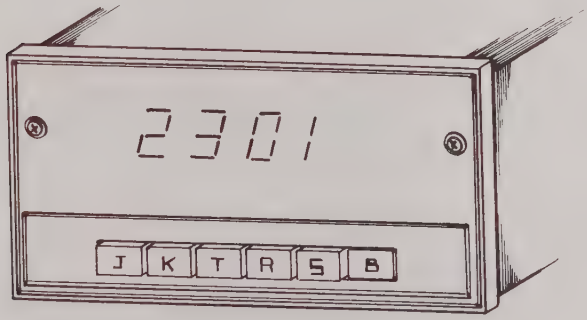


FIGURE 3-2. FRONT PANEL, MULTIRANGE UNIT (MODEL 403 SHOWN)

thermocouple wire. Otherwise, the binding posts may be bypassed, with signal input wires connected directly to the rear input terminals of the indicator in normal fashion. Note however that the rear of the instrument must be covered when making this connection in order to prevent thermal instability which results in inaccurate readings. A small hole may be drilled to thread the thermocouple wire through the rear cover near the input terminals, or if wire is smaller than 24 AWG, it can be routed between the edge of the case and rear cover. When using the multirange unit with the Model 407 Power Pack, the transfer standard (calibrator output) is effective only for the type thermocouple wire used to make the interconnection between the front panel binding posts and indicator input terminals. Refer to 3.6 for usage of the Models 406/407 Power Packs. Refer to 2.6.3 for indicator installation in a power pack unit.

3.4 USING THE 5-INPUT SWITCHING UNITS (MODELS 402/412)

The 5-input switching units accommodate five inputs of the same range as determined by the analog program module and LSI chip installed (refer to 1.1.1). Inputs are selected by a row of pushbuttons directly below the display. The pushbuttons are numbered 1-5. Pressing a particular pushbutton selects that input point for display. The pushbuttons are interlocked so that only one pushbutton is selected at one time.

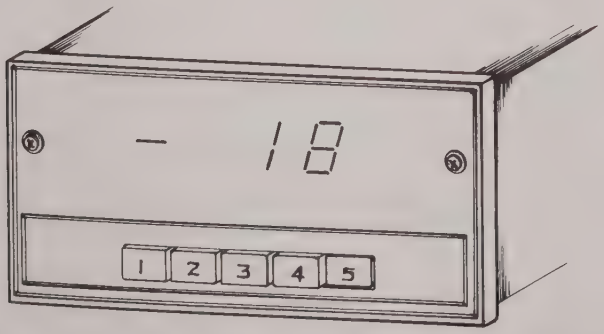


FIGURE 3-3. FRONT PANEL, 5-INPUT SWITCHING UNIT (MODEL 402 SHOWN)

3.5 USING THE EXTERNAL SWITCHING UNITS (MODELS 405/409) AND SWITCH ERROR BOARD (Option 001A)

The External Switching Units provide 10 switchable inputs to a single indicator. Inputs are selected by two rows of front panel pushbuttons labeled 1-10. (Special numbering available. Contact factory.) Pressing a particular pushbutton selects that input point for display. Each row of pushbuttons are interlocked so that only one pushbutton within that row is selected at one time. Installation of the Switch Error Board (Option 001A) into the measuring system provides switch error indication by blanking the display if two or more pushbutton switches (from two or more rows) are depressed simultaneously.

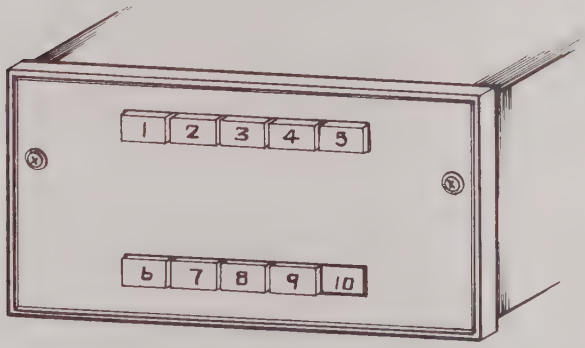


FIGURE 3-4. FRONT PANEL, EXTERNAL SWITCHING UNIT (MODELS 405/409)

3.6 USING THE POWER PACK UNITS (MODELS 406/407)

3.6.1 Battery Power Switch and Low Battery Indicator

The rocker type battery power switch is located on the bottom left portion of the instrument front panel. See Figure 3-5. When the top portion of the switch is pressed, battery power is supplied to the indicator. When the botton portion of the switch is pressed, battery power is removed from the indicator, and if the unit is plugged into an AC power source, AC power is then supplied to the indicator.

The low battery LED indicator is located directly left of the battery power switch. The LED indicator lights if the battery charge is low when operating the instrument from batteries. The LED indicator is off when the instrument is operating from AC (battery being charged), or when the battery is fully charged.

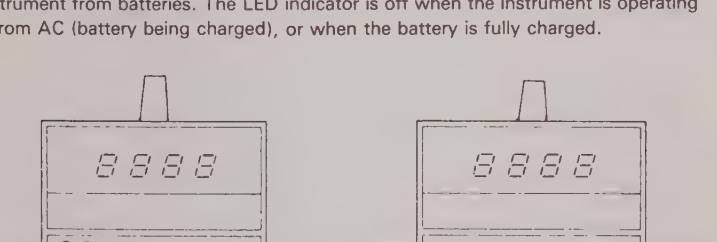


FIGURE 3-5. FRONT VIEW, MODELS 406 AND 407 POWER PACKS

3.6.2 Charging the Battery

To charge the battery, install the AC power cord into the input receptacle (see Figure 2-11) at the rear of the instrument and connect the cord to the appropriate AC power source as required by the instrument. (Be sure that the instrument is pro-

perly configured for the power voltage being used; refer to 2.4.1). The battery charges slightly faster when the battery power switch is off, but the battery charges with the switch in either position. A full charge should occur in 10-12 hours with the battery power switch in the OFF position. The battery, a 10V sealed lead-acid module, may be recharged up to 500 times, depending on the charge-discharge history. The unit operates about 2-5 hours continuously per charge.

3.6.3 Replacing the Battery

When it becomes necessary to replace the battery (p/n 400-4200-xx), the following steps are recommended.

a. Remove the rear cover of the carrying case (4 screws).

b. Remove all interconnecting cables between the indicator and Power Pack unit.

c. Slide the indicator and Power Pack unit out from the front of the carrying case.

d. Remove the front panel (2 screws) from the Power Pack unit and slide the pcb assembly out from the front.

e. Disconnect the battery connector from the printed circuit board (pcb).

f. On the top of the metal shield over the battery module (towards the rear) are two phillips head screws. Remove these two screws and lockwashers.

g. Lift the end of the metal shield (the end nearest the screw holes) until the battery is cleared; slide out old battery assembly.

h. Insert new battery in the same position while lifting metal shield for clearance.

i. Re-assemble the Power pack unit: Insert 2 screws with lockwashers on top of metal shield. Reconnect battery connector onto pcb contacts. Slide pcb assembly back into Power Pack unit case and re-install front panel (2 screws).

j. Re-install indicator and Power Pack unit into carrying case.

k. Re-connect interconnecting wires between Power Pack unit and indicator (binding post interconnections and ribbon cable to indicator P2).

l. Place rear cover over back of carrying case, align screw holes and install 4 screws.

3.6.4 Using the Model 407 Potentiometer

The Model 407 Power Pack/Potentiometer, after being calibrated per the procedures in Section 4, can be used as a calibration source for voltage or equivalent thermocouple output. Output impedance in all cases is ten ohms. AC or battery power can be used in the calibrator mode with the battery switch in either the OFF or ON position, although battery charging is faster in the OFF position. However, if the low battery LED is ON (lit), make sure the display is stable or place the unit on line operation to avoid runaround.

When the Model 407 is used to calibrate an instrument, ensure that the unit is using the correct range for the instrument being calibrated.

After the output connections have been made, apply power to the instrument (battery switch ON, or connect unit to AC power source). See Figure 3-5 for location of controls. Turn the calibrator source ON by pulling out the inner (smaller) knob of the FINE output control. The output is then adjusted to the desired value (read on the indicator display) by using the 10-turn COARSE output control knob and the 4-turn FINE output control knob as required.

3.6.4.1 Millivolt Source

Model 407 using the K1 range will output -10 mV to +25 mV, or the full K1 range. The readout on the display accurately represents the voltage at the front panel binding posts. The post material is brass, and care must be taken to use low thermal connections (copper wire) to avoid parasitic thermocouple effects. Calibrate

the external unit at the points desired by adjusting the COARSE and FINE controls until the indicator reads the desired voltage, then adjust the unit under calibration to read the appropriate value.

3.6.4.2 Thermocouple Transfer Standard

A Model 407 configured with a thermocouple range can be used as a precision, linearized voltage source for thermocouple indicator calibration. Only the range type configured in the instrument can be calibrated accurately. Note that reference junction integrity is maintained by the appropriate thermocouple lead wire or extension wire used for the interconnect between the Power Pack binding posts and indicator rear terminals (refer to 2.6.3.e) and between the Power Pack and unit under calibration. Thus, the instrument may be configured to another range with the thermocouple transfer standard applicable to that range by using the appropriate interconnections.

For example, if the Model 407 is to be used to calibrate type J instruments, the type J programming module and 7500 chip is installed in the indicator, and type J thermocouple wire used for the interconnect between Power Pack and indicator rear terminals and between Power Pack and unit being calibrated. Refer to 2.4.2 for range configuration and 2.6.3 for instructions on internal Power Pack connections.

To calibrate an instrument, use the COARSE knob to obtain a close reading of the desired value on the indicator display, then use the FINE control to obtain the precise reading. The unit being calibrated is then adjusted for the same reading. For example, if the ice point value for a type K instrument has to be set to 32 °F, use the COARSE and FINE controls to obtain a reading of 32 °F on the indicator display, then adjust the unit being calibrated to read the same.

For low level thermocouples such as S, R, and B, thermal effects on the input terminals may cause some error. To avoid drafts, place a cloth over the input terminals if necessary. In most cases, less than five minutes is required to stabilize for a precision calibration.

3.6.5 Using the Alarm Setpoint Board (Options 003A/004A)

Controls on the Alarm Setpoint Board include thumbwheel switches for set point value, a toggle switch for automatic/manual reset operation, and on 004A only, a miniature rotary switch for setting deadband.

The options provide Form C contacts at the rear, shown in Figure 2-18. When a limit is reached, as determined by the thumbwheel switch settings, the relay closes and the LED at the front of the board lights. If the comparator is in the Automatic Reset mode the relay will open and the LED turn off when the measured variable returns to a normal condition. If the comparator is in the Manual mode the relay must be reset manually after the measured variable returns to normal. A switch closure across the relay reset terminals, shown in Figure 2-18, resets the relay.

3.6.5.1 Selecting Setpoint Value

There are five thumbwheel switches accessible from the front panel, shown in Figure 3-6. For reference, these switches are identified as S1, and S2-A through S2-D. Four of these switches, S2-A through S2-D, are used to select the numerical setpoint (-3999 to +3999). Switch S1 is used to designate the setpoint as HI or LO.

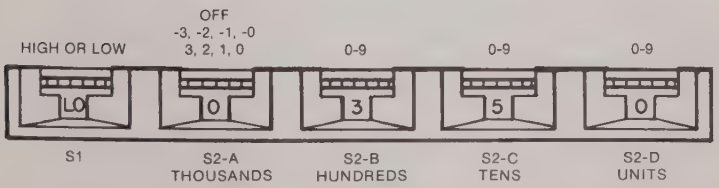


Figure 3-6. THUMBWHEEL SWITCHES ON ALARM SETPOINT BOARD (003A/004A)

As shown in Figure 3-6, S2-D select the thousands, hundreds, tens, and units respectively. Switch S2-A sets the most significant digit (thousands) from which the polarity of the setpoint is determined (+ or-). Switch S2-A also has an OFF setting to disable the setpoint. Switch S1 assigns the selected setpoint as HI or LO. To select a setpoint, simply dial the thumbwheel switches to the desired number. The example in Figure 3-6 shows a LO setpoint of + 350. To set a negative number, dial switch S2-A to -0, -1, -2, or -3 depending on the number of thousands desired.

The alarm relay is actuated when the input is at the exact setpoint setting. The HI/LO setpoint assignment determines what direction the input must take in order to trip the relay. If the setpoint is set HI, the alarm relay on the setpoint board will trip when the input value is equal to or greater than the setpoint value (input goes more positive). For example, for a HI setpoint of + 1000, an alarm trip will occur once the input value reaches + 1000 or more (e.g. + 1001, 1002...etc). If the setpoint is set LO, the alarm relay on the setpoint board will trip when the input value is equal to or less than the setpoint value (input goes more negative). For example, for a LO setpoint of -0099, an alarm trip will occur once the input value reaches -0099 or less (e.g. -0100, -0101...etc).

3.6.5.2 Selecting Manual or Automatic Reset

Toggle switch S4, accessible from the rear of the Alarm Setpoint board, is used to select automatic or manual reset of the alarm relay. See Figure 2-18 in Section 2.

Switch positions AUTO/MAN are etched on the board below the switch. When in the AUTO position, the alarm relay will reset automatically once the measured variable no longer exceeds the setpoint. When in the MAN position, the alarm relay remains tripped even if the measured value no longer exceeds the setpoint. The relay is reset by an external momentary contact switch (normally open) connected to the reset input terminals provided by TB1 on the board (see Figure 2-18).

Note that if the external manual reset switch remains closed, the relay remains untripped regardless of alarm conditions that may still exist or the position of switch S4.

3.6.5.3 Setting Deadband (004A)

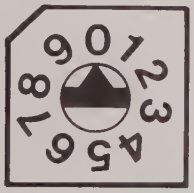
Option 004A Alarm Setpoint board is provided with a miniature rotary switch (S3) located on the printed circuit board behind the alarm LED. Switch S3 selects

the desired value of deadband (hysteresis) from 0 to 9. The Alarm Setpoint board must be removed from the chassis to gain access to this switch. A small bladed screwdriver is recommended to actuate the switch. A small notch or triangle within the screwdriver slot (shown in Figure 3-7) indicates the setting.

Settings on the switch represent deadband units which are used to set the return limit after the initial setpoint has been exceeded. The deadband setting is negative for HI setpoints; positive for LO setpoints. A setting of zero indicates no deadband.

The AUTO/MAN switch (S4) must be in the AUTO position for control applications.

The table below shows deadband operation with HI and LO setpoints:



SWITCH SET AT ZERO

FIGURE 3-7. SWITCH S3

Deadband set to 6:

SETPOINT	READING	ALARM
HI +0100	100 99-94 93	YES YES NO
LO +0100	100 101-106 107	YES YES NO

SECTION 4

CALIBRATION

4.1 TEST EQUIPMENT

a. Thermocouples: a DC calibrator capable of supplying voltages up to 100 mV with better than one microvolt resolution is required. A stable ice bath, accurate to 0.05°F, is also needed.

b. K1, K2, K3, K4, K5 Ranges: a DC calibrator (see item a above) is required, except an output of up to 25V is necessary (K4 range).

c. I_1, I_2, I_3 Ranges: a current calibrator with 1 μA resolution from 4 to 50 mA is required.

d. RTD Ranges: 000.00 to 400.00 ohm calibration pot with 0.01 ohm resolution is required.

e. TH ranges: 1000.0 to 30,000.0 ohm calibration pot with 1.0 ohm resolution is required.

4.2 CALIBRATION PROCEDURE

In all cases, allow instrument to warm up for 30 minutes before calibrating.

4.2.1 THERMOCOUPLES

a. Prepare test wires for ice bath as shown in Figure 4-1.

b. Connect the DC calibrator and ice bath to the instrument as shown in the set-up diagram in Figure 4-2.

c. Refer to calibration chart in Figure 4-3 and perform calibration.

EXAMPLE: For Type K thermocouple. Connect the DC calibrator to instrument +V and -V. Apply 0.000 mV and adjust Front Panel Zero (R44) to give a display of 32°F or 0°C. Apply 54.845 mV and adjust + Span (R45) to give a display of 2500°F. R44 and R45 are visible at the upper left of the display with the front panel plexiglas removed.

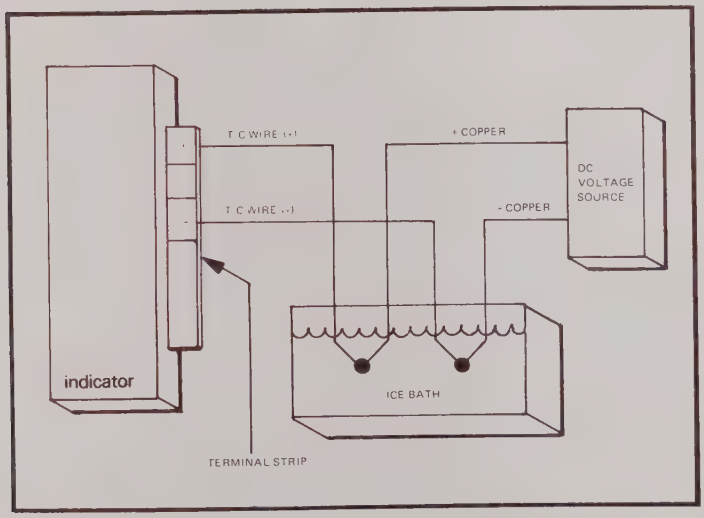


FIGURE 4-1. CALIBRATION SET-UP

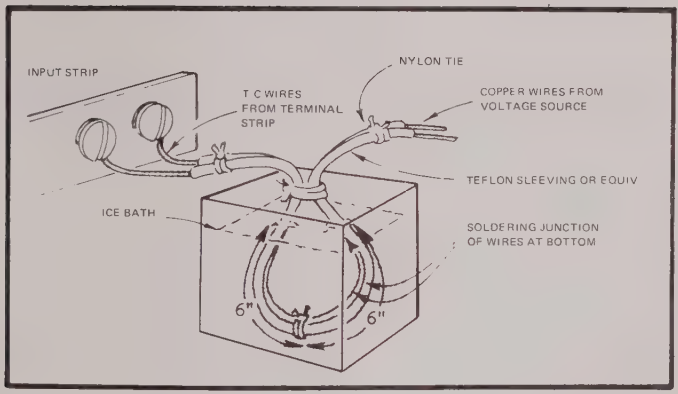


FIGURE 4-2. PREPARING WIRES FOR ICE BATH

NOTE: The B thermocouple output below 912°F (488°C) is only 1.3 μV/°F (2.4 μV/°C). While the instrument linearity is excellent above 912°F, the "B" μV table will better approximate lower temperatures.

4.2.2 LINEAR VOLTAGE RANGES

4.2.2.1 K1, K2, K3, and K4 RANGES

Calibration consists of two mandatory pot adjustments, ZERO and +SPAN. These adjustments are located on the upper left behind the plexiglass front panel (extract two front panel screws). The pots are labeled with their respective function on the PC board.

If required, −SPAN can also be adjusted (R14). This pot is located at the rear of the instrument between the input terminal strip and P2. For all applicable ranges, −SPAN display readings should be verified with the appropriate input voltage per the calibration chart and the −SPAN pot (R14) adjust if necessary.

a. Connect the DC calibrator to the +V and −V terminals of the instrument.

b. Perform calibration per the calibration chart, inputting the appropriate voltage and adjusting the appropriate pot for the desired display reading. Calibration must be performed in the following sequence, (a) Zero, (b) +SPAN, and (c) −SPAN (if necessary).

4.2.2.2 K5 RANGE

a. Connect the voltage calibrator to the +V and −V terminals (rear panel) of the instrument.

b. Apply 0 volts and adjust the OFFSET pot, located on the analog programming module, to the desired minimum reading. If necessary, the ZERO pot located behind the plexiglass front panel (extract two front panel screws) can be used to fine tune this adjustment.

c. Apply +5 volts and adjust the three span pots as required for the maximum desired reading. The three pots in order of degree of refinement are the C (coarse) pot and FINE pot (both located on the analog programming module), and the +SPAN pot located behind the plexiglass front panel.

d. Re-apply 0 volts input and recheck the display reading. If required, repeat steps b and c above.

4.2.3 CURRENT TRANSMITTER RANGES

4.2.3.1 I1 and I2 Ranges

Calibration consists of two pot adjustments, ZERO and +SPAN. These adjustments are located on the upper left behind the plexiglass front panel (extract two front panel screws). The pots are labeled with their respective function on the PC board.

a. Connect the current calibrator to the +I and −I terminals of the instrument.

b. Perform calibration per the calibration chart, inputting the appropriate current and adjusting the appropriate pot for the desired display reading. The ZERO adjustment should be performed first and the +SPAN adjustment performed next.

4.2.3.2 I3 Range

a. Connect the current calibrator to the +I and −I terminals of the instrument.

b. Apply 4 mA and adjust the OFFSET pot, located on the analog programming module, to the desired minimum reading. If necessary, the ZERO pot located behind the plexiglass front panel (extract two front panel screws) can be used to fine tune this adjustment.

c. Apply 20 mA and adjust the three span pots as required for the maximum desired reading. The three pots in order of degree of refinement are the C (coarse) pot and FINE pot (both located on the analog programming module), and the +SPAN pot located behind the plexiglass front panel.

d. Re-apply 4 mA and recheck the display reading. If required, repeat steps b and c above.

RANGE	SENSOR TYPE	INPUT	ADJUST	READ	INPUT	ADJUST†	READ	INPUT	READ
J 2J	Iron-Constantan	0 mV 0 mV	Zero Zero	32°F 0°C	39.407 42.283	Span Span	1300°F 750°C	-7.519 -7.659	-300°F -190°C
K	Chromel-Alumel	0 mV 0 mV	Zero Zero	32°F 0°C	54.845 52.398	Span Span	2500°F 1300°C	-4.381 -3.553	-200°F -100°C
T 2T	Copper-Constantan	0 mV 0 mV	Zero Zero	32°F 0°C	20.801 20.252	Span Span	750°F 390°C	-5.341 -5.439	-300°F -190°C
R	Platinum – Platinum 13% Rhodium	0 mV 0 mV	Zero Zero	32°F 0°C	19.518 20.878	Span Span	3000°F 1750°C	– –	– –
S	Platinum – Platinum 10% Rhodium	0 mV 0 mV	Zero Zero	32°F 0°C	17.347 18.504	Span Span	3000°F 1750°C	– –	– –
B	Platinum 30% Rhodium Platinum – 6% Rhodium	0 mV 0 mV	Zero Zero	32°F 0°C	13.763 13.585	Span Span	3300°F 1800°C	– –	– –
FC	Iron Constantan (DIN)	0 mV 0 mV	Zero Zero	32.0°F 0.0°C	53.064 mV 50.320 mV	Span Span	1650.0°F 860.0°C	-8.022 mV -8.006 mV	-320.0°F -195.0°C
CC	Copper-Constantan (DIN)	0 mV 0 mV	Zero Zero	32.0°F 0.0°C	31.492 mV 33.954 mV	Span Span	1040.0°F 595.0°C	-5.405 mV -5.510 mV	-300.0°F -190.0°C
E	Chromel-Constantan	0 mV 0 mV	Zero Zero	32.0°F 0.0°C	81.273 mV 76.357 mV	Span Span	1950.0°F 1000.0°C	-8.768 mV -8.273 mV	-324.0°F -180.0°C
P3 P4	Platinum 100Ω RTD (DIN)	100.00Ω 100.00Ω	Zero Zero	32.0°F 0.0°C	390.38Ω 390.38Ω	Span Span	1562.0°F 850.0°C	18.53Ω	-328.0°F -200.0°C
P5 P6	Platinum 1000RTD (USA)	100.00Ω 100.00Ω	Zero Zero	32.0°F 0.0°C	381.19Ω 381.19Ω	+ Span + Span	1472.0°F 800.0°C	17.02Ω 17.02Ω	- 328.0°F - 200.0°C
C3, C4	Copper RTD	9.04 6.73 9.04 6.73	Zero -Span Zero -Span	32°F -76°F 0°C -60°C	16.91 16.74	+Span +Span	400.0°F 200.0°C	–	
TH	Thermistor	T1-100K T2-25.425K	Zero	32°F	T1-100K T2-1.602K	ISpan	212°F	–	–
TC	Thermistor	T1-100K T2-25.425K	Zero	0°C	T1 100K T2-1.602K	+Span	100°C		
I1	4-20 mA Transmitter	4.000 mA	Zero	-.00%	20.000 mA	Span	100.00%	–	
I2	10-50 mA Transmitter	10.000 mA	Zero	- 00%	50.000 mA	Span	100 00%	–	–
I3	4-20 mA Transmitter	4.000 mA	Offset*		20 000 mA	C & Fine Span *		–	
K1	-10 mV to +25 mV Linear	0 mV	Zero	- 000 mV	25 000 mV	Span	25.000 mV	10 000 mV	-10 000 mV
K2	-100 mV to +250 mV Linear	0 mV	Zero	-.00 mV	250.00 mV	Span	250.00 mV	-100.00 mV	100 00 mV
K3	-1V to +2 5V Linear	0 mV	Zero	-.0000V	2.5000V	Span	2 5000V	-1 0000V	-1 0000V
1000 mV (408, 418)	-0.5V to +1.0V Linear	0 mV	Zero	-.0 mV	1.0000V	Span	1000.0 mV	-500.0 mV	-500.0 mV
K4	-10V to +25V	0 mV	Zero	- 000V	25 000V	Span	25 000V	-10 000V	-10 000V
K5	0-5V	0mV	Offset*		5.000V	C & Fine Span *		–	–

* Refer to text

† Although minus span adjust is normally not required, R14 may be adjusted

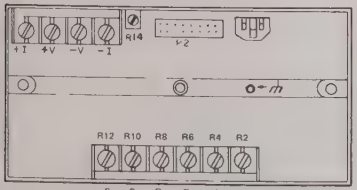
FIGURE 4-3. CALIBRATION CHART

4.2.4 RTD AND TH RANGES

a. Connect resistor(s) as indicated in Figure 2-11.
b. Refer to calibration chart and perform calibration.

4.2.5 Multirange Units

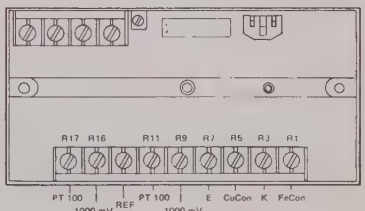
The following charts lists calibration adjustments for multirange instruments. Complete and accurate calibration for all ranges requires that the instrument be returned to the factory. Touch-up span calibration can be achieved by adjusting the appropriate span pot accessible from the rear. On these units, the zero pot (behind the front panel) may be adjusted for a particular range at the expense of remaining ranges being slightly off at zero (ice point). It may be necessary to re-adjust ice point for the particular type thermocouple being used (particularly common with types R, S, and B). Always adjust ice point before adjusting full scale. Minus span pot R14 may be adjusted if desired for a particular range, but is common for all ranges. Input and nominal calibration values are the same as shown in the calibration chart with this section.



TC TYPE	ICE POINT ADJUST	FULL SCALE ADJUST
B	Zero*	R12
J	Zero*	R2
K	Zero*	R4
T	Zero*	R6
R	Zero*	R8
S	Zero*	R10

*Zero adjust is on front panel

MODELS 403, 415



RANGE TYPE	ZERO ADJUST	FULL SCALE ADJUST
Fe Con	Zero*	R1
K	Zero*	R3
Cu Con	Zero*	R5
E	Zero*	R7
PT3, PT4	PT R17	R11
1000mV	mV R16	R9

*Zero adjust is on front panel

MODELS 408, 418

4.2.6 POWER PACK 406 AND 407

a. Connect front panel inputs the same as indicator rear inputs.

b. Adjust according to calibration chart. Model 407 potentiometer switch must be OFF.

c. Models 406 and 407 may be calibrated while line charging or running on batteries.

4.2.7 Analog Output

The Analog Output board is provided with three pots for calibration. See Figure 4-4. Use the calibration set-up shown in Figure 4-2 to calibrate the Analog Output board. Connect a known source to the indicator from which the Analog Output board is converting. Connect a DVM with 100 μV resolution to the output terminals of the Analog Output board. Adjust R18 (zero), R14 (+full scale), and R13 (-full scale) with the appropriate input in that order until the millivolt output agrees with the indicator display in the following fashion:

Analog Output = display counts x 1mV. (This applies to degrees, but not to tenths of degrees.)

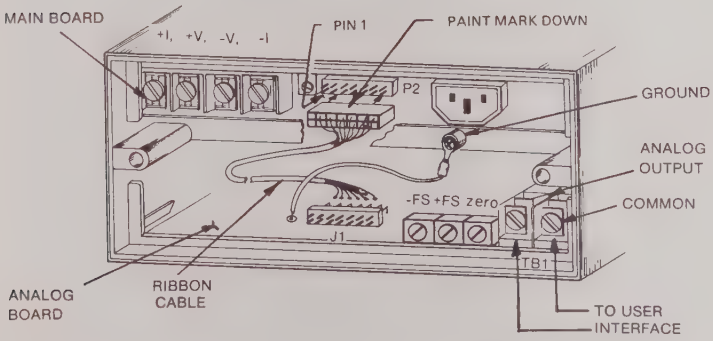


FIGURE 4-4. REAR VIEW, OPTION 005A CALIBRATION POTS

SECTION 5

THEORY OF OPERATION

5.1 INTRODUCTION

All Series 400 indicators accept a variety of inputs (thermocouple, voltage, current, resistance) and converts them to degrees or other engineering units. Dual slope integration is used for low noise and auto-zero circuitry assures drift- free performance.

The instrument utilizes (LSI) PMOS semiconductor technology. All digital logic including thermocouple and RTD linearization tables is contained in one of two optional ion-implanted PMOS integrated circuits. A solid-state planar LED display is driven by on-chip decoders. Strobes provide a bright digital indication in degrees Fahrenheit or Celsius, or other engineering units.

5.2 DUAL SLOPE A/D CONVERSION

Refer to the schematic of analog circuits (Figure 5-1) and diagram of dual slope technique (Figure 5-2). Before each conversion (T_o), S2 and S3 are closed. The auto-zero and zero-cross detector circuits "close the loop" around the integrator, establishing a starting point for the integration.

During T_1, S_2 and S_3 are opened, S1 is closed, and the integrator is allowed to ramp up (down for + E_{IN}). After a known number of clock pulses S1 is opened, S2 is closed, and a short pause occurs to settle capacitor charging.

During T_3, S5 is connected (S4 if + E_{IN}) and the integrator ramps back toward zero at a constant rate. The amount of time (counts) required to return to zero is proportional to the input voltage. After zero-crossing the system returns to auto-zero.

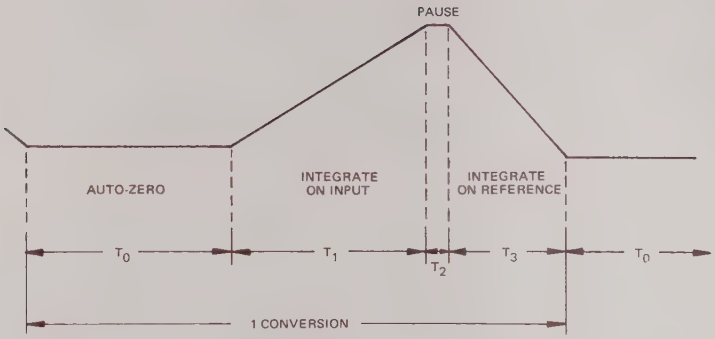


FIGURE 5-1. DUAL SLOPE TECHNIQUE

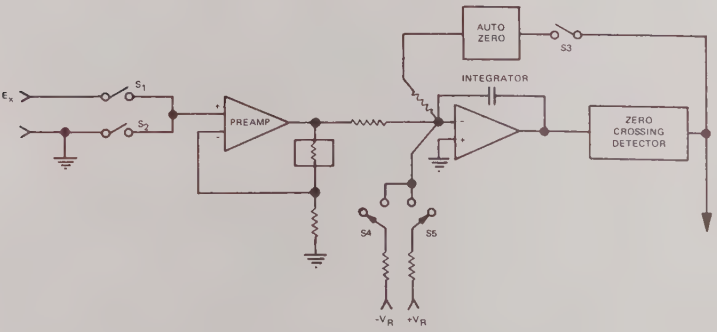


FIGURE 5-2. ANALOG CIRCUITS SHOWING AUTO-ZERO

5.3 CIRCUIT DESCRIPTION, BASE UNIT

5.3.1 Power Supply and Regulator

Refer to schematic 400-6180 or 400-6190 in back of manual. AC power is connected at P1, filtered for RFI, and connected to the power transformer, T1. The rectified secondary voltage provides +11 VDC on C4 and C5 (LED display power) and -11 VDC on C6. The two amplifiers of Z8 drive pass transistors Q1 and Q2. If excessive current is drawn through Q1 or Q2 resistors R3 and R9 limit the peak currents, thus protecting the supply.

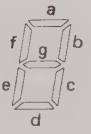
Potentiometer R13 adjusts the power supply voltage. Positive span is adjusted with R45 with the front panel removed, and negative span is adjusted independently by R14 with the rear cover removed.

5.3.2 Display and Driver

The seven segments (a through g, see sketch below) of the common-cathode LED displays are driven by seven emitter-follower Darlington transistors (Q9 through Q15). Current is limited by Z11 (resistor network) to illuminate segments a through g. Z10 provides digit drive and selection at the appropriate multiplex time.

Level shifter Q8 is used for leading zero blanking control in conjunction with S2. "DIP" switch S2 is used to select drive to an appropriate decimal point for the range being used. One pole of S2 may also be used to configure °F or °C display for any of the temperature measuring ranges.

DISPLAY SEGMENTS



5.3.3 Digital Logic

Z9 is a PMOS digital integrated circuit operating from the regulated +7.2 and -7.2 voltages. Pins 15 through 20 are digit strobes for driving digit selection drivers. Pins 23 through 29 provide segment data for generating the display. Pin 6 of Z9, a clock input, receives the 400 kHz clock, generated by C18, R38, R39 and Z7 pins 11-15. Pin 33 is a power-on reset pin used in conjunction with R41 and C21. Pin 33 clears internal logic and prepares the dynamic logic for the first conversion. Pin 35 is the "start convert" line and delays conversion by a time constant generated by Q7, R40 and C20. Pins 37 through 40 provide the A/D conversion switching logic (see block diagram, page 5-2) for S5, S4, S3, and S1. Pins 6 through 9 of Z9 are used in conjunction with the analog program module (J3) to configure the unit for the appropriate range type.

5.3.4 Analog Operation

The Analog Program Modules (APM) condition, scale, and offset various range inputs. For thermocouples a reference junction, gain scaling and break detection circuitry are provided. Current sources and bridge completion are included for PT, CU and TH ranges. Scaling and filtering for K ranges, and shunt and offset circuitry for I ranges are also provided.

The input filter consists of R15, R46, R47, and C9, C10, and C11. The input to Z2 is alternately switched from the filtered input to R17. Potentiometer R19 gives an adjustable low level offset through voltage divider R18 and R17. R21 and R20 provide offset adjustment for low level preamplifier Z2. Gain feedback resistor is contained on the APM between APM pins 2 and 23. R25 and R33 provide reference current for reference integration as switched by Z3. C22 compensates Z4 (400's). Z5 is the auto-zero preamplifier, R34 and R35 set the gain for Z5. R31, R32 and C14 are compensation and hold components for auto-zero error correction. Pins 8 and 9 of Z3 provide the S3 switching function. R29 adjusts the DC level and R30 provides the bias for Q6, a source follower. R24 couples the error correction to the summing node. Q3 and the APM generate reference junction correction current for thermocouple ranges. This current and bridge completion offsets for other ranges, are fed from the APM pin 8 to the integrator summing node via series CMOS switch. Z6 and Z7 pins 10 and 9, plus positive feedback (hysteresis) resistors R36 and R37 comprise the zero crossing detector circuitry.

I/O connector P2 provides interface connections for power pack and BCD options.

5.4 POWER PACKS (MODELS 406/407)

Refer to schematic 406-6200 or 407-6100 in back of manual. The two power pack options contain circuitry for float charging the sealed lead-acid cells, as well as circuitry for converting the battery voltage into a usable form for the main board power supply.

C1, C2, CR1, and C3 provide a voltage doubling of the raw AC signals from the transformer on the main board. Z3 is a protected constant voltage regulator, which is trimmed to the nominal charge voltage of 11.75V at the anode of CR4. R1, R2, and R3 adjust the voltage of Z3, and CR4 protects Z3 from battery current when not in a charging mode. Switch SW1 disconnects the battery from loads in the "OFF" position (open). Resistors R4 and R5, and Op-Amp Z1 Pins 12, 13, and 14 put a "trickle" load on the battery to sense low voltage. If the unit is on, and the battery drops below about 9.3 volts, LED CR8 is turned on and current limited by R7. The raw battery voltage is fed back to the + unregulated node of the main board by CR2. This voltage is in parallel with any unregulated voltage that may be supplied by the transformer on the main board.

Z2, C4, and R6 form a free running oscillator and driver for Q1 and Q2 at about 5 kHz. Q1 and Q2 provide a "charge pump" effect to generate the lower current - unregulated supply through CR5, CR6, CR7, C5, C6, and C7. This voltage is decoupled from the main board with CR3.

Front panel inputs on the 406 and 407 are wired internally to the rear input terminals on the main board. For thermocouple units, appropriate thermocouple extension wire is used for this purpose to maintain reference junction integrity to the front binding posts.

The Model 407 contains additional circuitry for calibration output. 10-turn wirewound pot R10 provides a stable "coarse" adjust. R10 is biased correctly by R8, R9, and R11. R13 injects offset current to R10 via pot R12, thus providing a fine adjustment. R12 is a single-turn composition unit ganged with a two-pole switch SW2. With R12/SW2 in the most counterclockwise position, SW2 pins 1 and 2 are open, disconnecting the calibrator output from both the instrument and the front panel terminals. The unit is used as a conventional indicator in this mode. SW2 pins 3 and 4 effectively short the calibrator, preventing interactive ground currents from flowing. Z1 pins 10, 9, 8 provide high impedance referencing of the pot circuit to ground, Z1 pins 2, 3, 1 provide a buffered output and drive the output divider R14 and R15. Z1 pins 5, 6, 7 and R16, R18, and R17 generate an opposing current to the output divider and prevent offset from occurring in return wires to the instrument.

5.5 SWITCH ERROR (Option 001A)

The Switch Error board detects simultaneous pushbutton selection from any two rows. When a switch error occurs, the display is blanked. This is accomplished by sensing the resistance within the switching matrix.

If two or more pushbuttons are selected, the 100 kohm resistor from each switch becomes in parallel, causing a net resistance of 50 kohms or less. The Switch Error board senses this resistance as an input to transistor Q2. The base of transistor Q2 is biased on with 50 kohms or less, which in turn, turns on Q1. When Q1 conducts, +7.2 volts is applied to the reset input of the LSI chip (pin 33) causing the instrument to halt display strobing, which blanks the display.

5.6 BCD DATA OUTPUT (Option 002A)

Option 002A provides fully isolated parallel digital outputs which are T^2L compatible. The LSI device (Z9) on the main 400A board generates a serial BCD output on pin 32. This data is in a pulse width modulated format and includes polarity and overload information. The data enters the 002A board through J1

pins and is level shifted and amplified by R3, R4 and Q3. Opto isolator Z1 is driven by Q3 and provides isolation of data. The receiving side of Z1 is shaped and buffered by R10 and Z3 (7, 6). The pulse width modulated data (6 4-bit words) is inverted by Z3 (14, 15) and presented to the input to a 24 bit shift register comprised of Z6, Z7, and Z8.

Clocking information for the shift register is provided by pin 7 of one-shot Z4. One shot time is adjusted for ~9 μsec which is halfway between a "1" and a "0" pulse width. Thus, a "1" or "0" is clocked into the shift register for each data pulse.

The second half of one-shot Z4 (pin 10) provides a 3.5 msec pulse triggered off the first data bit. This pulse is slightly wider than the entire 24-bit shift sequence and disables the data valid (DAV) output flag until data shifting has been completed. When DAV goes true (high) all parallel digit outputs are stable and can be read correctly by an external printer or peripheral.

Command control of the data is handled with two lines. HOLD sets the R-S flipflop comprised of Z5 (1, 2, 3) and Z5 (11, 12, 13). This flipflop is reset at every update period unless the HOLD line is held low. When the flipflop is set, A5 is "on" and Opto Z2 is also on. FET Z4 also turns on and forces pin 35 of Z9 on the main board high, or in a continuous hold position. When HOLD is released, the main board one-shot of Q7, R40, and C20 functions normally and begins a new encoding.

The data request (DAR) line requests a positive edge to initial BCD data updating. This edge is detected by Z13 (3) and latched by Z13 (9). Z13 is reset with the 3.5 msec pulse from Z4 (10) after every ready. To eliminate the necessity for continuous positive edges on the DAR if continuously updated output is desired, the continuous output pin (COP) is provided. If this line is switched to DAR, BCD output updates automatically with each encoding.

The power supply for the 002A option is derived from the main board 400 kHz clock. This square wave is buffered by Q1 and Q2 and isolated with C2, R2, and T1. The signal is rectified and filtered on T1's secondary by CR2, CR3, CR4, CR5, and C5. Zener CR6 regulates the output to provide a TTL compatible supply and logic reference.

5.7 ALARM SETPOINT (Option 003A/004A)

J1 is the interconnect to P2 on the Model 400/410 main board and is paralleled with P1 to facilitate "daisy chaining" of additional options. Pin 5 of J1, serial data out from the 400A/410A, is converted to parallel BCD data by Z1, Z4, Z5 and Z6. This parallel data (sign and magnitude) are applied to side A of BCD adder string Z7, Z8, Z9 and Z10. The least significant digit (LSD) of Side B of the adder is connected to Z19. A quad nor gate, Z19 acts like a multiplex gate, adding the BCD value of S3 (0 - 9) when appropriate (See Figure 5-3).

The output of the BCD adder (Z7, Z8, Z9, Z10) connects to Side A of the comparator chain (Z11, Z12, Z13 and Z14). Side B is connected to a second BCD adder (Z15, Z16, Z17 and Z18). Side A input to the adder is connected to switch module S1 and S2-A through S2-D, which are used to enter the desired setpoint. The B input to adder (Z15, Z16, Z17 and Z18) has the LSD connected to the output of Z20. Z20 works the same way as Z19 and applies a 0 - 9 from S3 (hysteresis switch) when logic conditions are satisfied (See Figure 5-3).

Z3, Z21 and Z22 provide a logic "1" at Z23 (pin 5) according to Figure 5-3. The clock input of Z23 is supplied by the delay one-shot (Z1 pin 9), allowing serial data to settle before updating. Z23 (pin 1) is the "set point true" signal that drives Z23 (pin 8) and Q1, Q2. These transistors, in turn, actuate K1 and illuminate CR2, indicated set point true.

In automatic reset position of S4, Z23 (pin 10) is connected to Z23 (pin 2, $\overline{Q}$) and is automatically returned to zero (Q1 and Q2 off) when the next "not out-of-limit" condition exists.

In manual mode, reset is accomplished by shorting across "remote reset" terminals. This short causes the 400kHz clock (impressed on primary of T2) to be coupled across the guard to T1 and back to the reset pin of Z23 (pin 10). In the manual mode, reset is accomplished only by remote or local actuation after process variable has returned within limits.

HI/LO	POLARITY SETTING	ALGEBRAIC 400 /410 READING*	ALARM Z23-5
HI	+	- or + <	0
HI	+	+ >	1
LO	+	+ >	0
LO	+	- or + <	1
HI	-	- <	0
HI	-	+ or - >	1
LO	-	+ or - >	0
LO	-	- <	1

*relative to set point

EXAMPLE: If the HI/LO limit on the thumbwheel switch is set on "HI" and the numerical polarity setting is plus, a 400 /410 reading of any plus value greater than the thumbwheel setting places a logic "1" at Pin 5 of IC Z23.

FIGURE 5-3. TRUTH TABLE

5.8 ANALOG OUTPUT (Option 005A)

J1 is the interconnect to P2 on the Model 400/410 main board and is paralleled with P1 to facilitate "daisy chaining" of additional options. Pin 1 of J1 feeds a 400kHz clock signal to the inputs of three stages of hex CMOS inverter Z1. These outputs are paralleled and connected to the primary of T1 and to the inputs of the other 3 stages of Z1. The outputs of these three stages are paralleled and connected to the other side of T1 primary. This produces a 22 volt squarewave at the secondary. Spikes are filtered by C3. Diodes CR1 through CR4 form a full-wave bridge. C4 and C5 provide a filtered ± 10 volts to power the analog and digital circuitry.

Transistor Q1, IC Z2, and associated components provide isolation for the coded serial BCD data from the 400A/410A. Z3 inverts and buffers the data, routing it to Z4 and Z8. Z6, Z7, and Z8 are 8-bit serial to parallel shift registers with integral output latches. The serial data is applied on Pin 2 of Z8. A shift-clock generated by Pin 7 of Z4 is applied to Pin 3 of Z6, Z7, and Z8. The output latch strobe is formed by Pin 9 of Z4 and is used to update the data after all 6 decades have been shifted into the serial-to-parallel register.

Parallel BCD data are applied to comparators Z11 through Z14. The other side of these comparators is connected to the BCD counters Z15 through Z18. These counters form divide-by-4000 timing information which is compared with BCD data. The "greater than" (A > B) output Z11 (Pin 13) provides a pulse output with a 100 Hz repetition rate. This pulse width is proportional to the magnitude of the BCD data (see Figure 5-4). This pulse is applied to the quad-analog switch (see Figure 5-5) via Z3 and Z9 to provide drive phase.

Z5 and associated components provide a ±6.4 VDC reference. The appropriate polarity reference is applied through R15 or R16 and span adjust pots R13 or R14. Z19 and associated components provide output buffering and filtering to give smooth dc out.

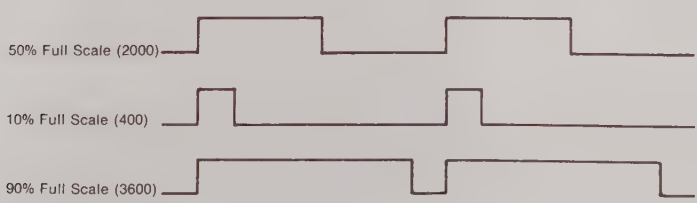


FIGURE 5-4. PULSE WIDTH/BCD DATA MAGNITUDE

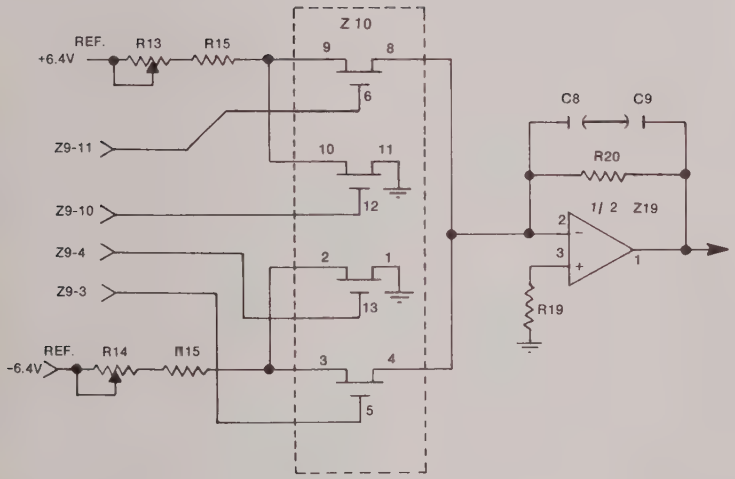


FIGURE 5-5. QUAD-ANALOG SWITCH (Z10)

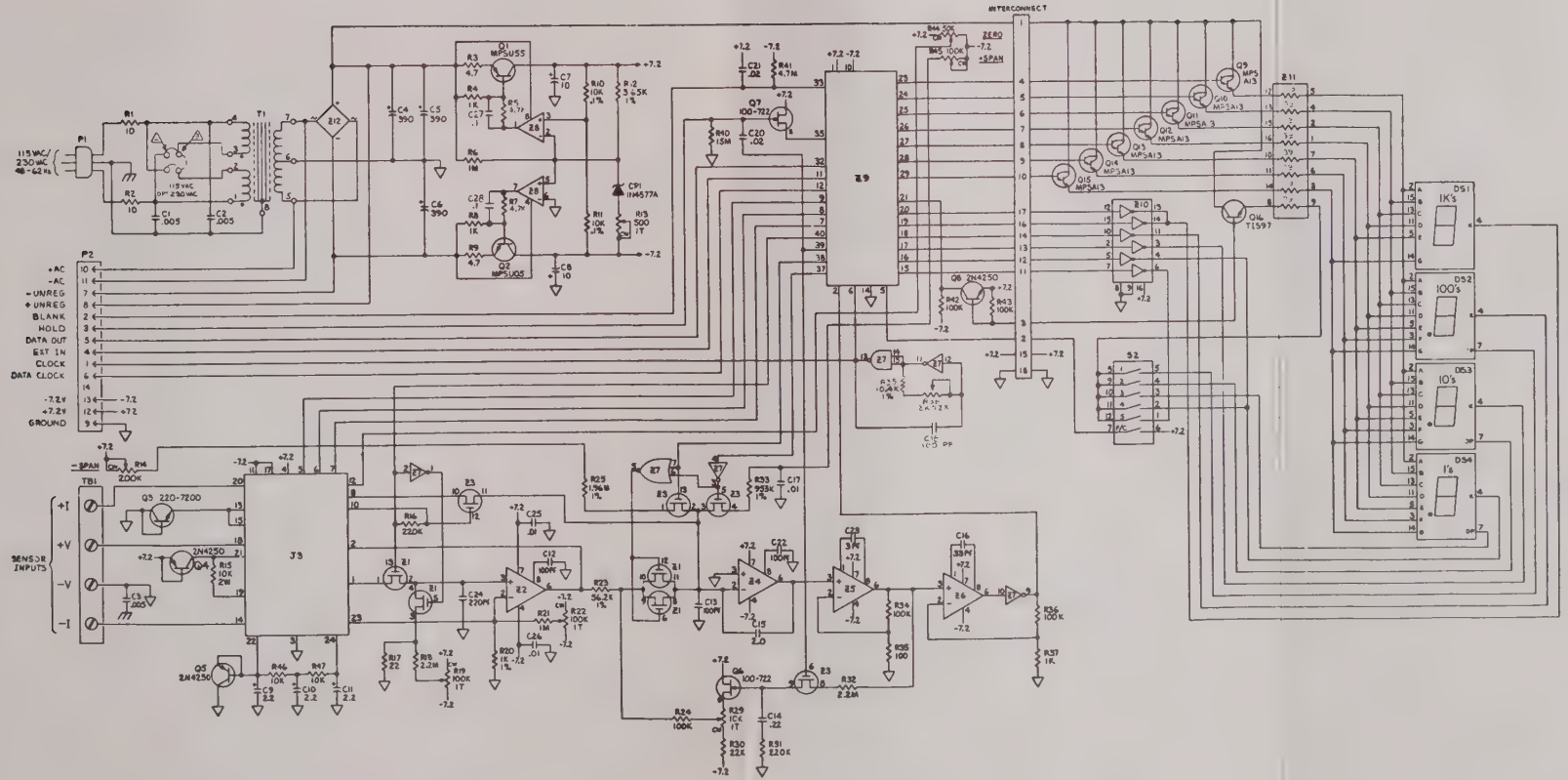
SECTION 6

DRAWINGS

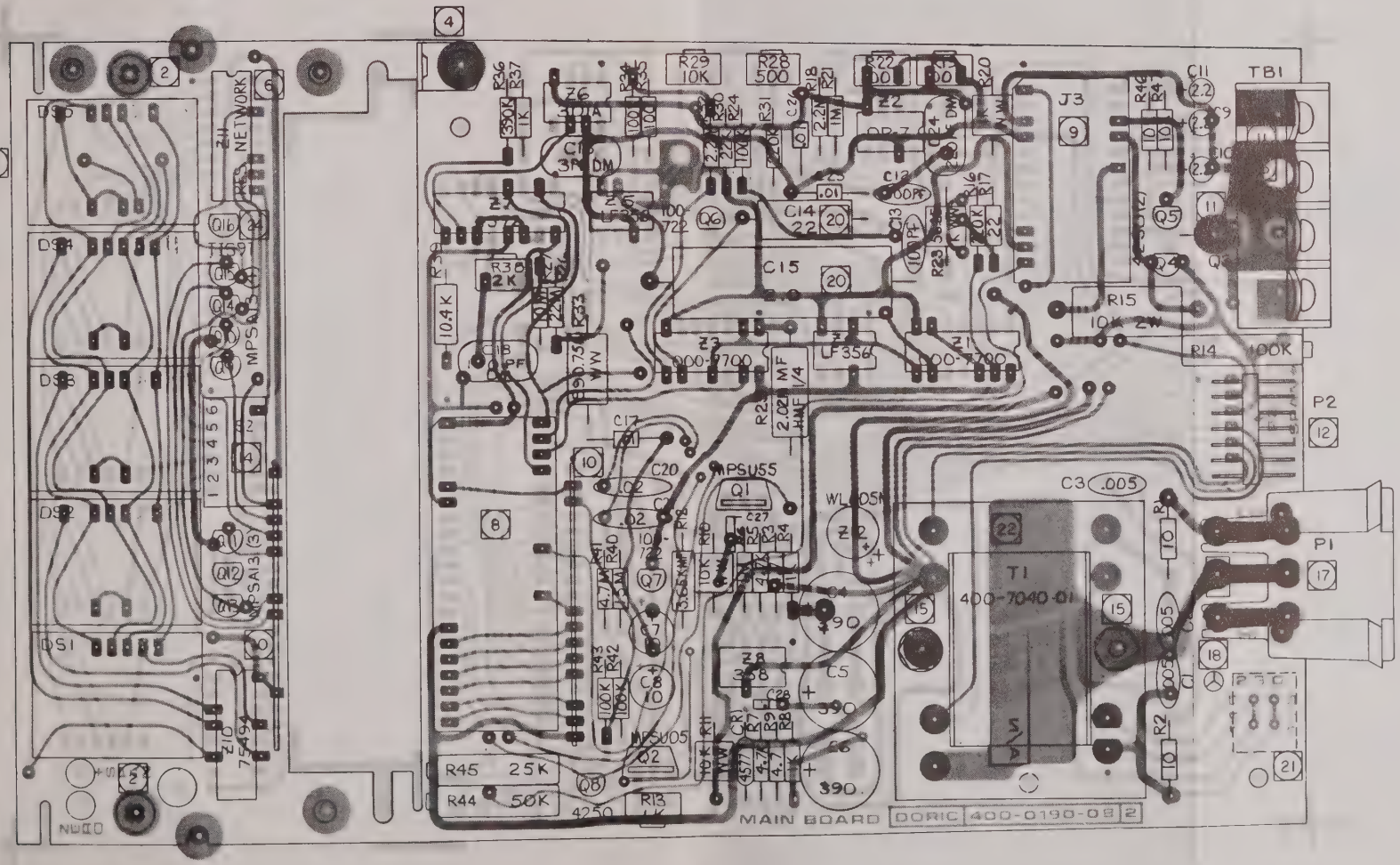
DRAWING	TITLE	TYPE* DRAWING	PAGE
400-4180-XX	Main Board, Model 400	A	6-2
400-6180-XX	Main Board, Model 400	S	6-3
400-4190-XX	Main Board, Model 410	A	6-4
400-6190-XX	Main Board, Model 410	S	6-5
400-4130-XX	DIN Multirange Board	A	6-6
400-6130-XX	DIN Multirange Board	S	6-7
400-4420-XX	Switch Error Indicator Board	A	6-8
400-6420-XX	Switch Error Indicator Board	S	6-9
400-4430-XX	Switch Board	A	6-10
400-6430-XX	Switch Board	S	6-11
400-4440-XX	BCD Data Board	A	6-12
400-6440-XX	BDC Data Board	S	6-13
400-4450-XX	Multirange Board	A	6-14
400-6450-XX	Multirange Board	S	6-15
400-4580-XX	External Switching Unit	A	6-16
400-6580-XX	External Switching Unit	S	6-17
406-4200-XX	Power Pack, Model 406	A	6-18
406-6200-XX	Power Pack, Model 406	S	6-19
407-4100-XX	Power Pack Pot, Model 407	A	6-20
407-6100-XX	Power Pack Pot, Model 407	S	6-21
409-4100-XX	RTD Switching Unit	A	6-22
409-6100-XX	RTD Switching Unit	S	6-23
000-7840-XX	Dimensional Outline	O	6-24
400-440X-XX	Setpoint Board	A	6-25
400-6400-XX	Setpoint Board	S	6-26
400-4410-XX	Analog Output Board	A	6-27
400-6410-XX	Analog Output Board	S	6-28
411-400X-XX	Model 411	A	6-29

*A = Assembly S = Schematic O = Outline

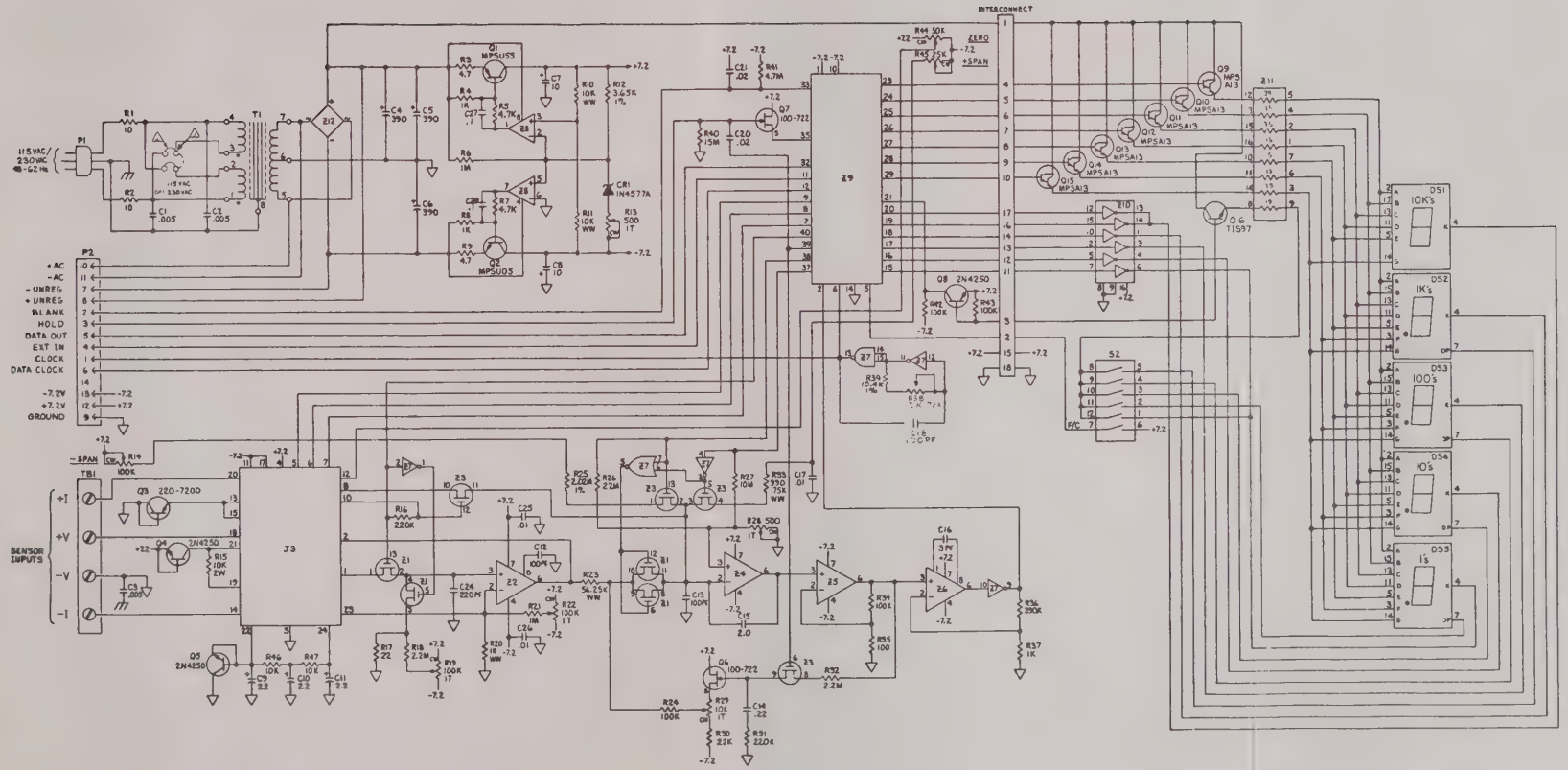
MAIN BOARD 400
ASSEMBLY 400-4180-09



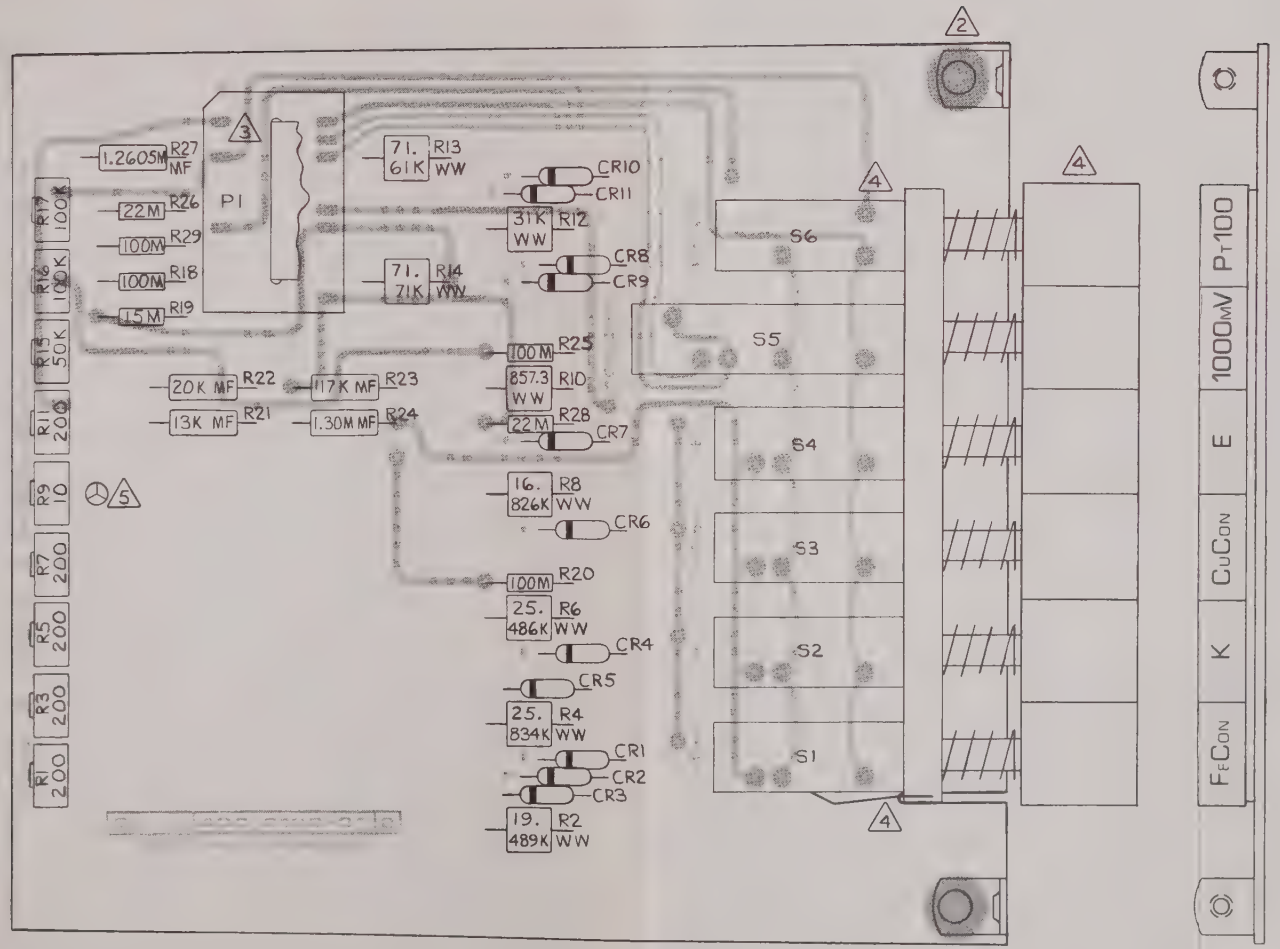
MAIN BOARD 400
SCHEMATIC 400-6180-08



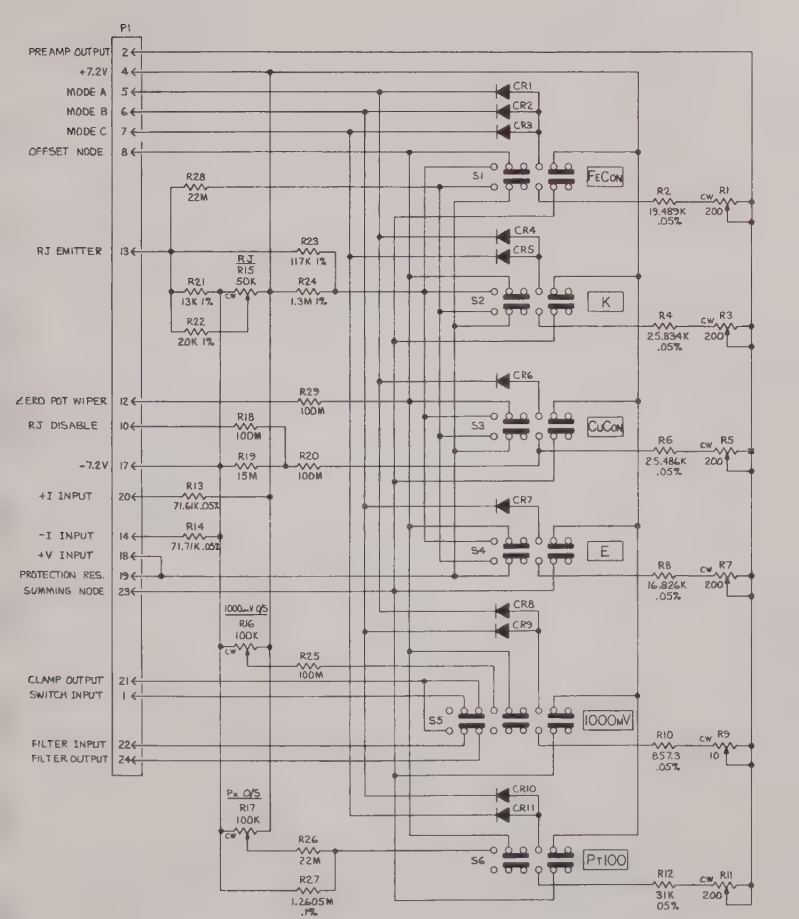
MAIN BOARD 410
ASSEMBLY 400-4190-09



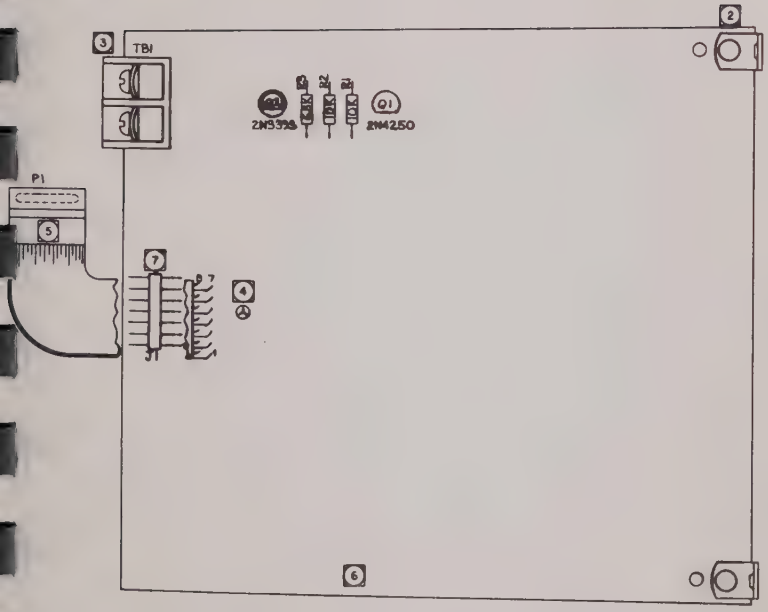
MAIN BOARD 410
SCHEMATIC 400-6190-08



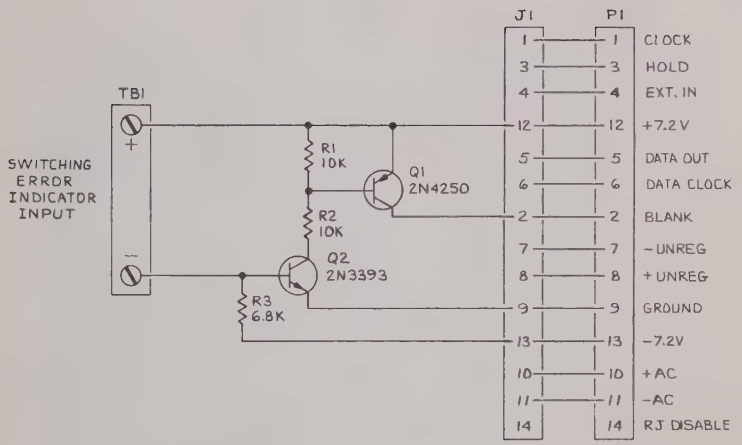
DIN MULTIRANGE BOARD
ASSEMBLY 400-4130-00



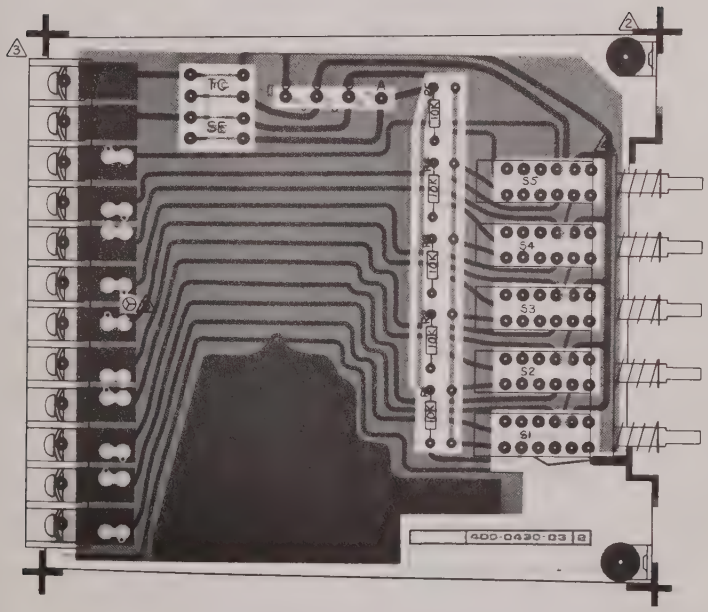
DIN MULTIRANGE BOARD
SCHEMATIC 400-6130-00



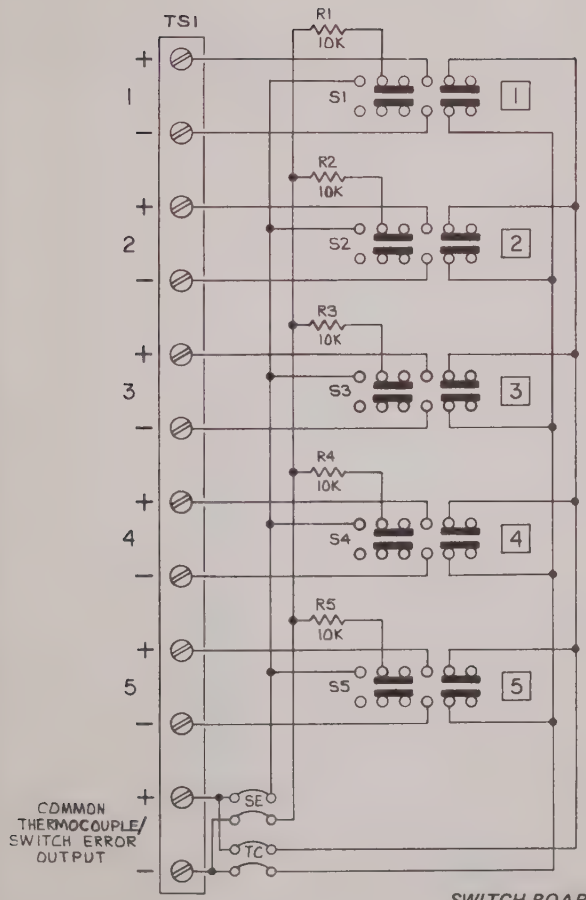
ASSEMBLY-
SWITCH ERROR
INDICATOR
400-4420-018



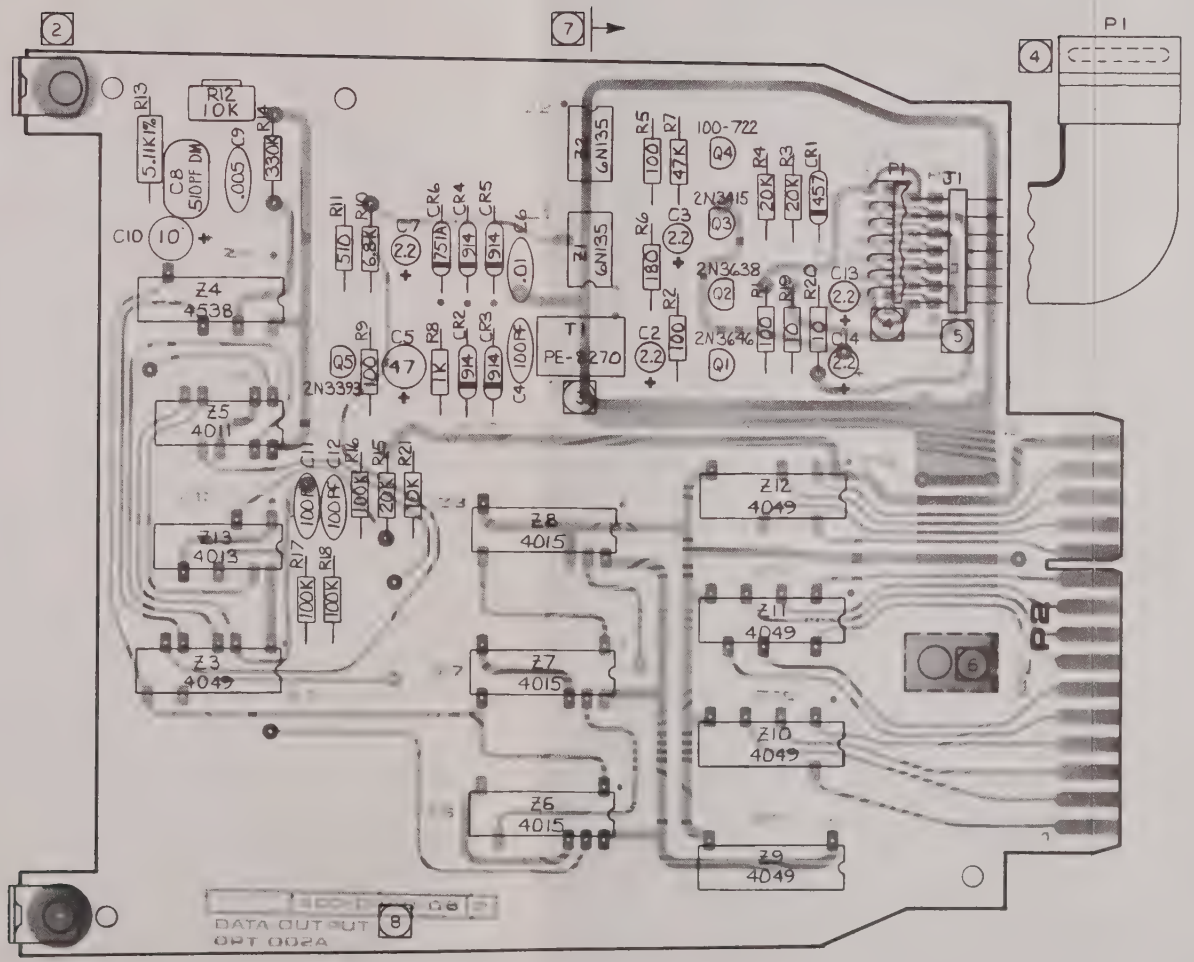
SWITCH ERROR INDICATOR
SCHEMATIC 400-6420-00



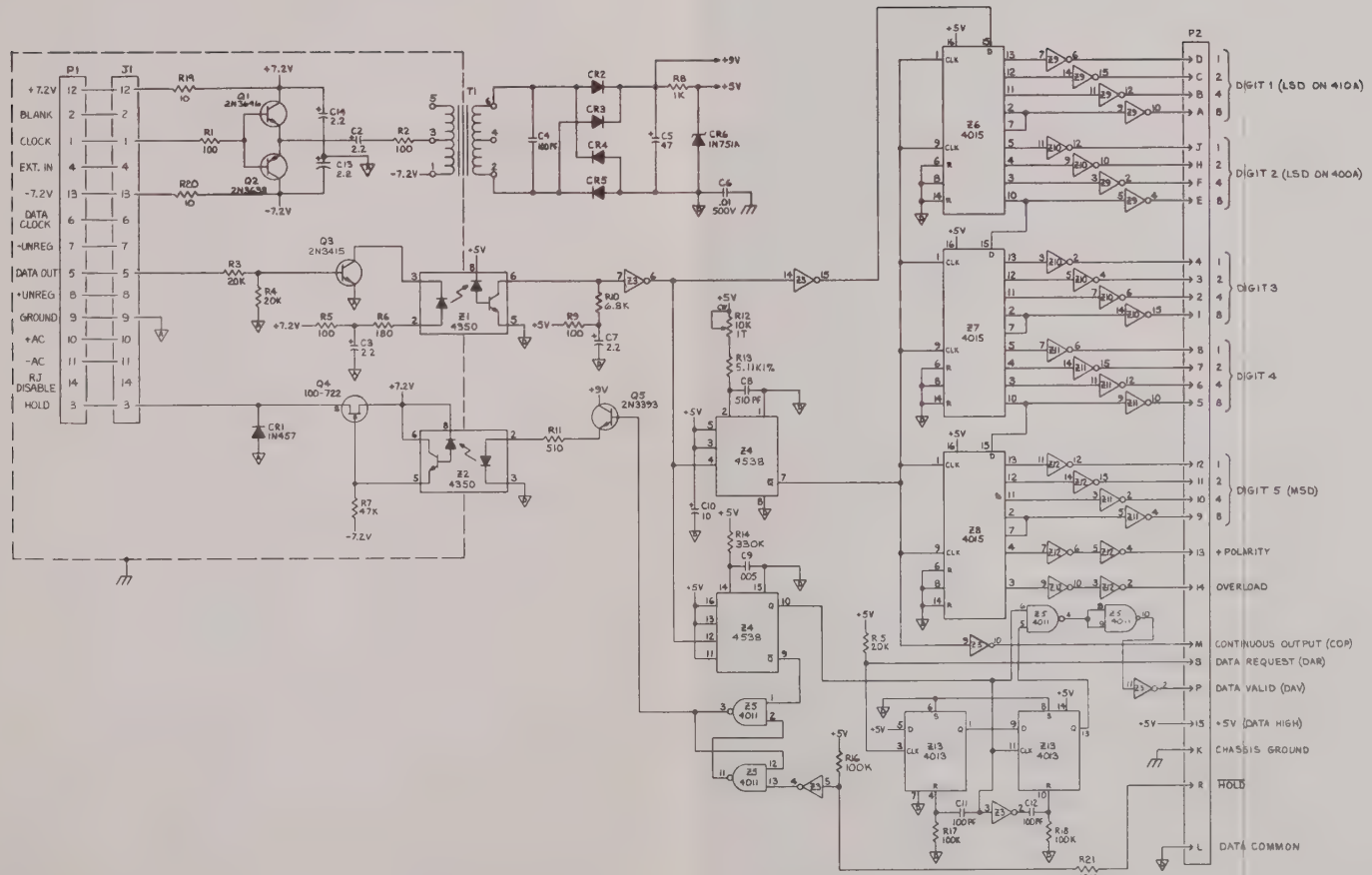
SWITCH BOARD
ASSEMBLY 400-4430-01



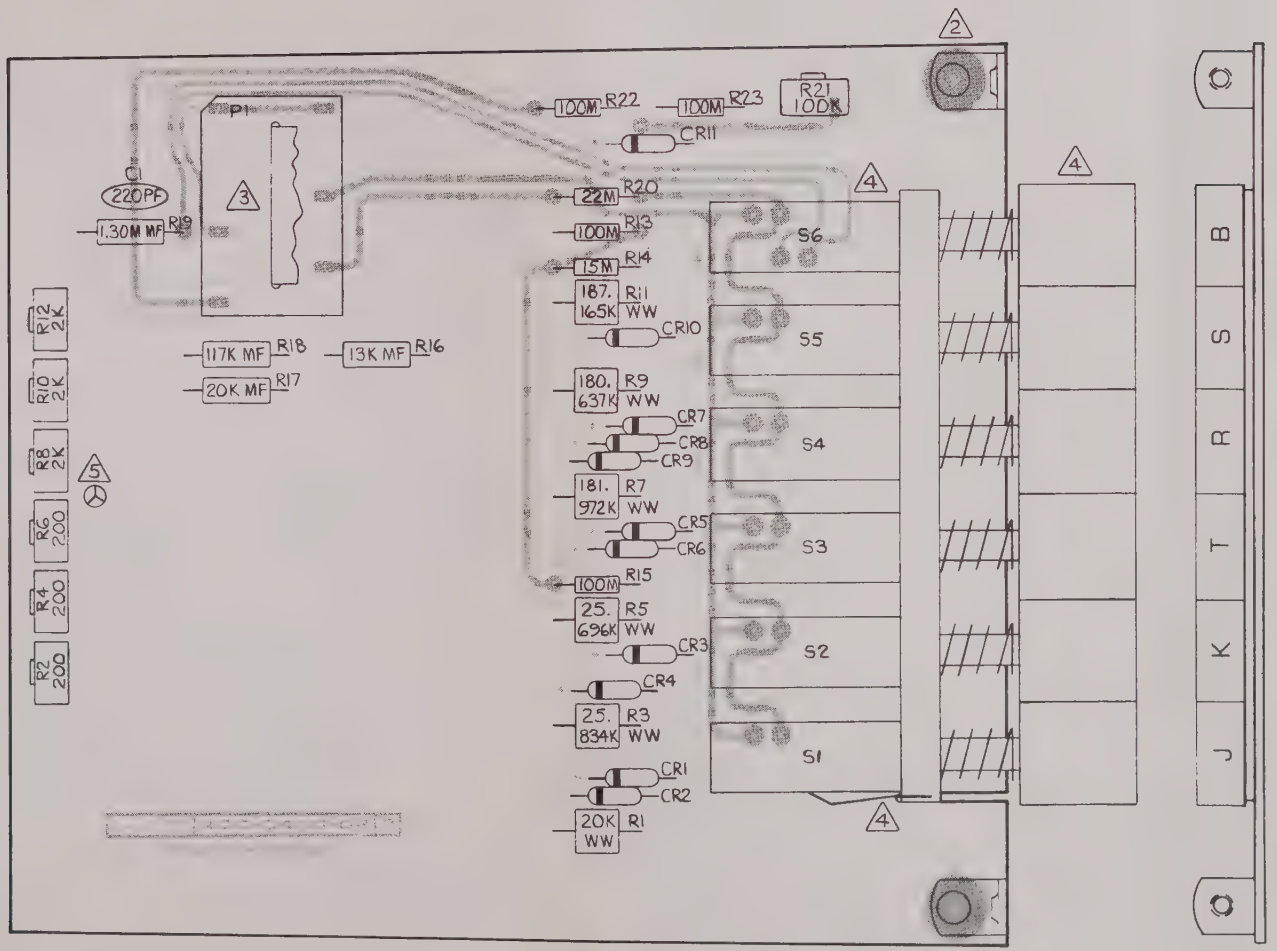
SWITCH BOARD
SCHEMATIC 400-6430-21



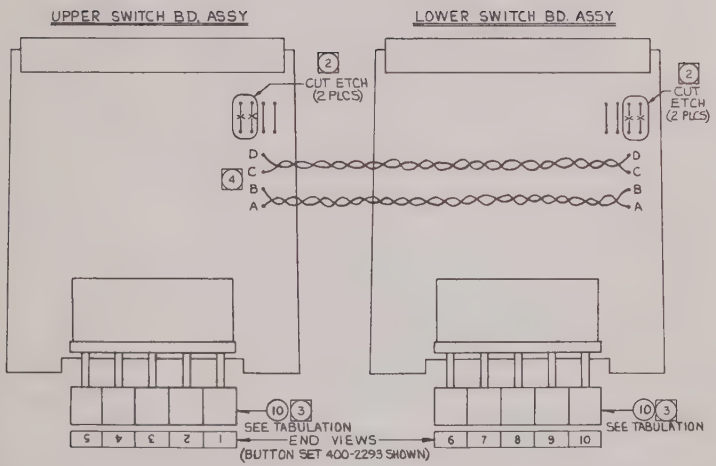
BCD DATA OUTPUT BOARD
ASSEMBLY 400-4440-06



BCD DATA OUTPUT BOARD
SCHEMATIC 400-6440-05

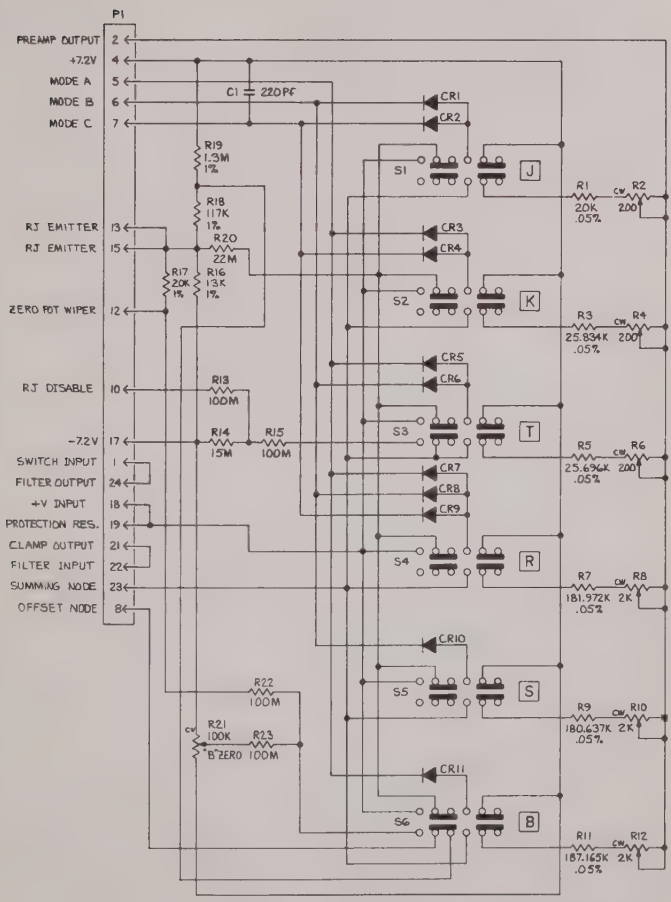


MULTIRANGE BOARD
ASSEMBLY 400-4450-01

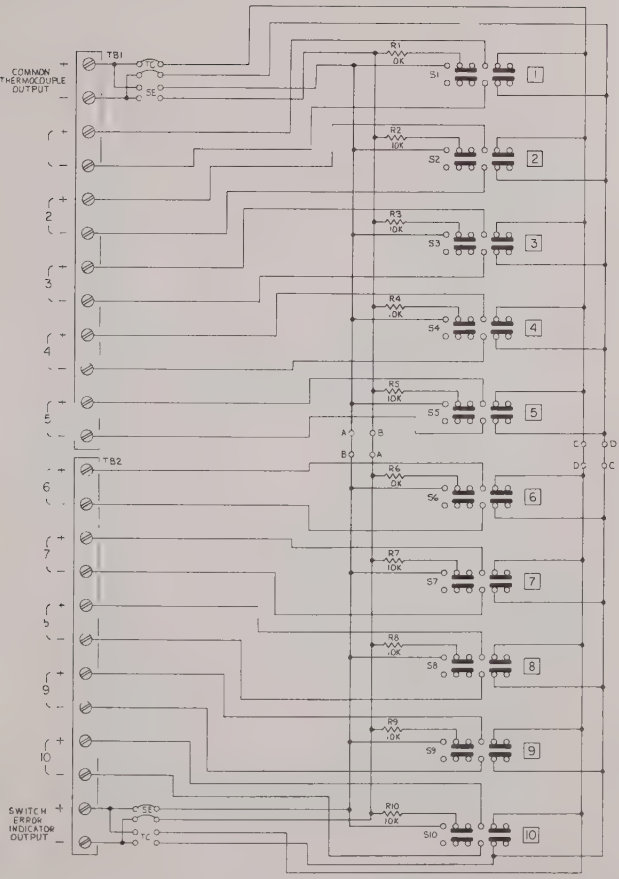


BUTTON SET # LABEL TABULATION 3		
FOR MODEL	USE BUTTON SET	USE LABELS
405A (1-10)	400-2293-XX	400-2250-XX & 400-2251-XX
405A(11-20)	400-2294-XX	400-2252-XX & 400-2253-XX
405A(21-30)	400-2295-XX	400-2254-XX & 400-2255-XX
405A(31-40)	400-2296-XX	400-2256-XX & 400-2257-XX
405A(41-50)	400-2297-XX	400-2258-XX & 400-2259-XX

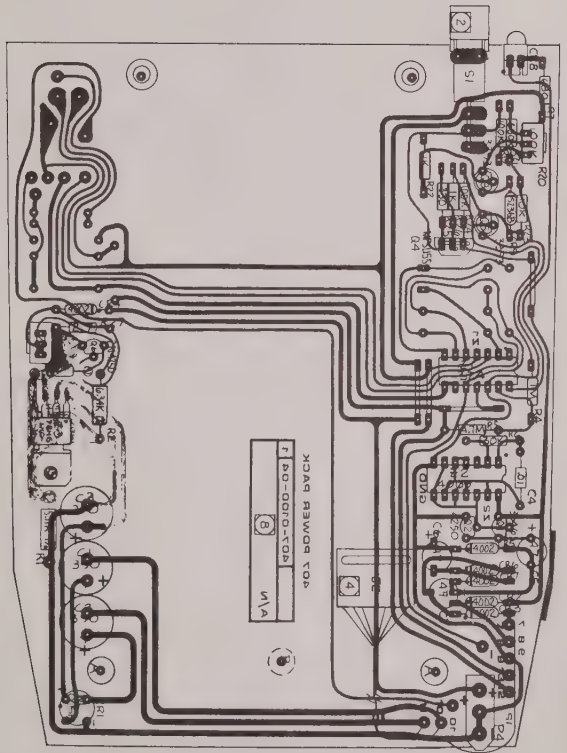
EXTERNAL SWITCHING UNIT ASSEMBLY 400-4580-01

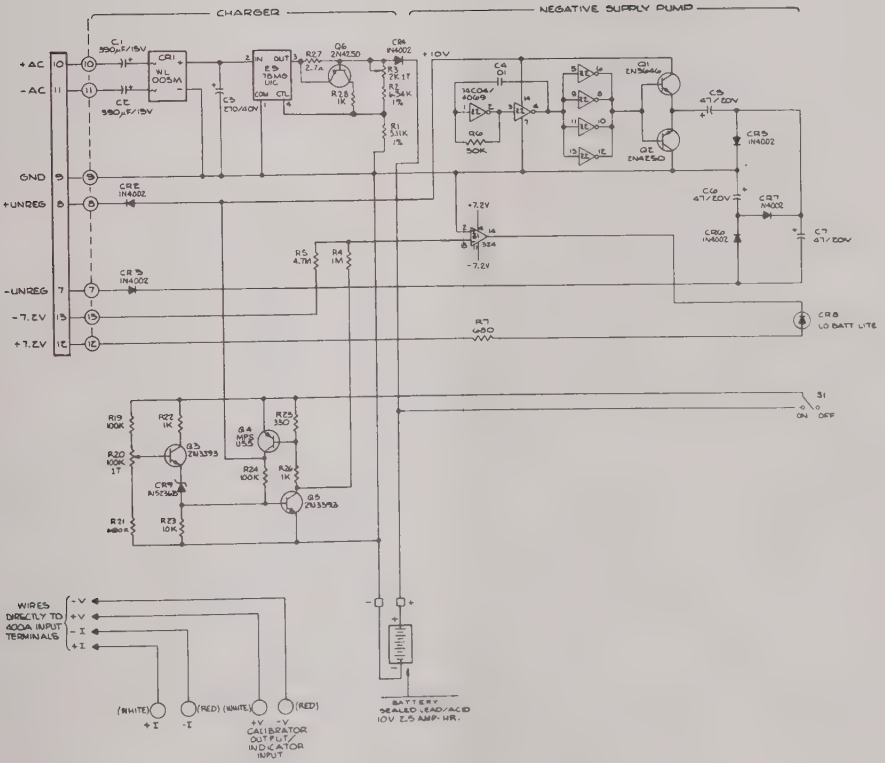


MULTIRANGE BOARD
SCHEMATIC 400-6450-01

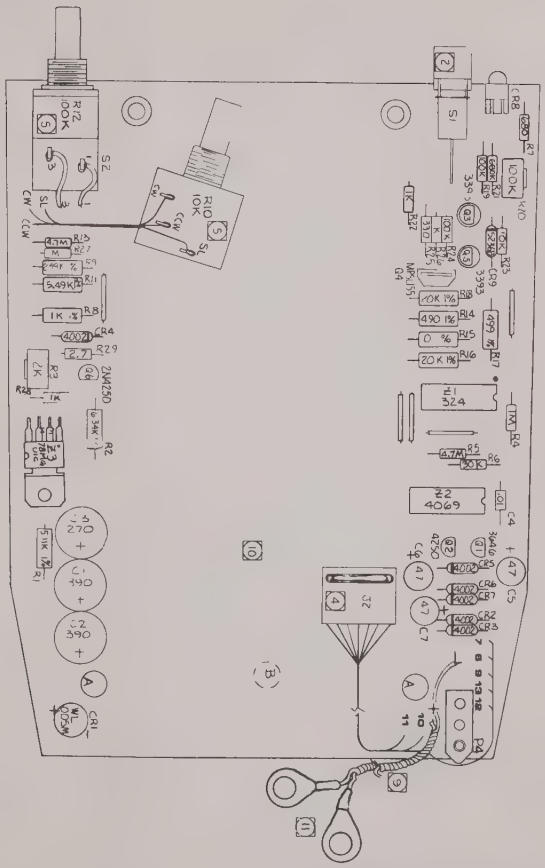


EXTERNAL SWITCHING UNIT
SCHEMATIC 400-6580-00

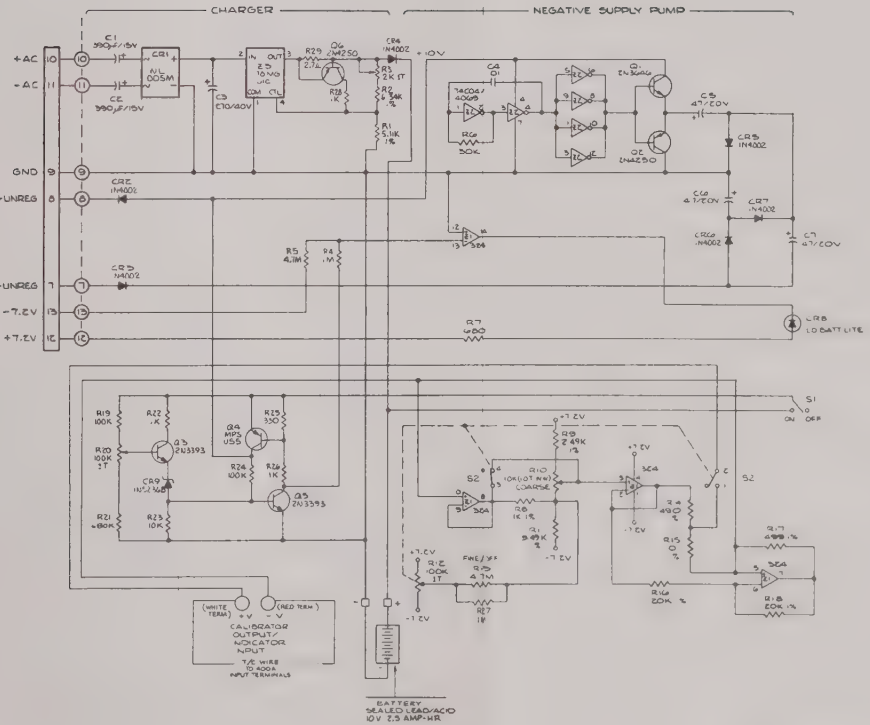

POWER PACK
ASSEMBLY 406-4200-03



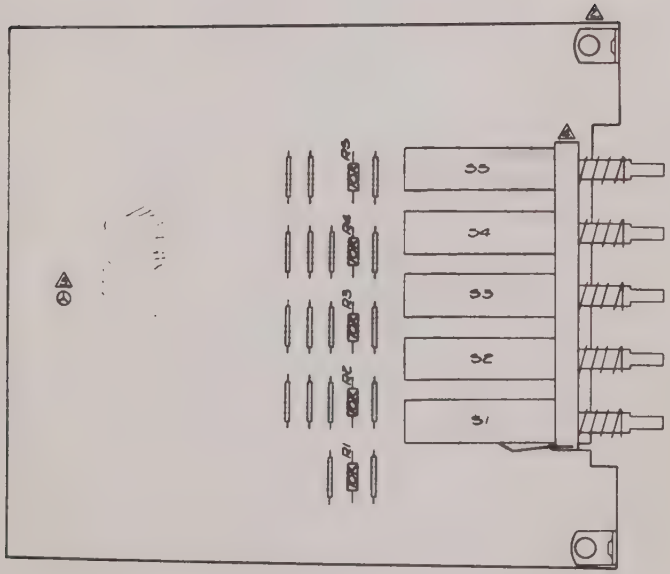
POWER PACK
SCHEMATIC 406-6200-06



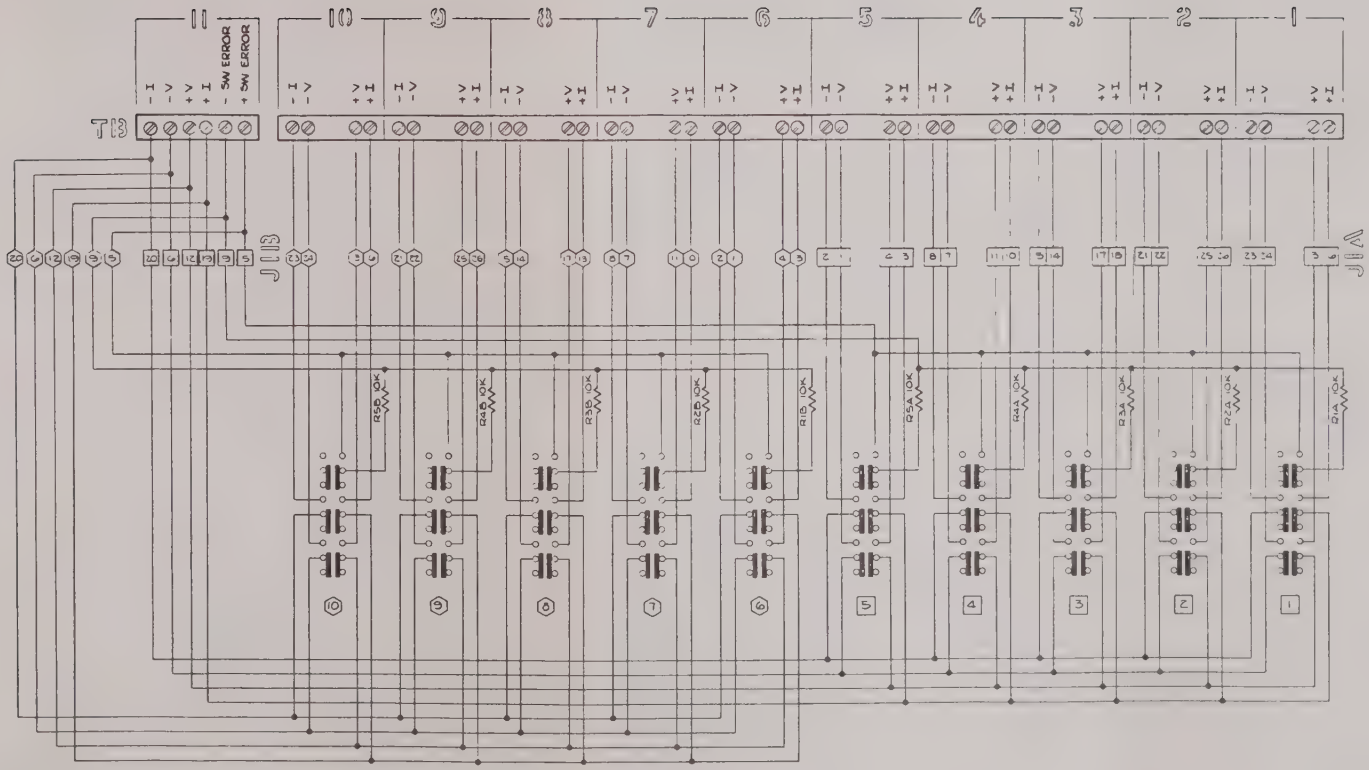
POWER PACK POTENTIOMETER ASSEMBLY 407-4100-05



POWER PACK POTENTIOMETER SCHEMATIC 407-6100-05



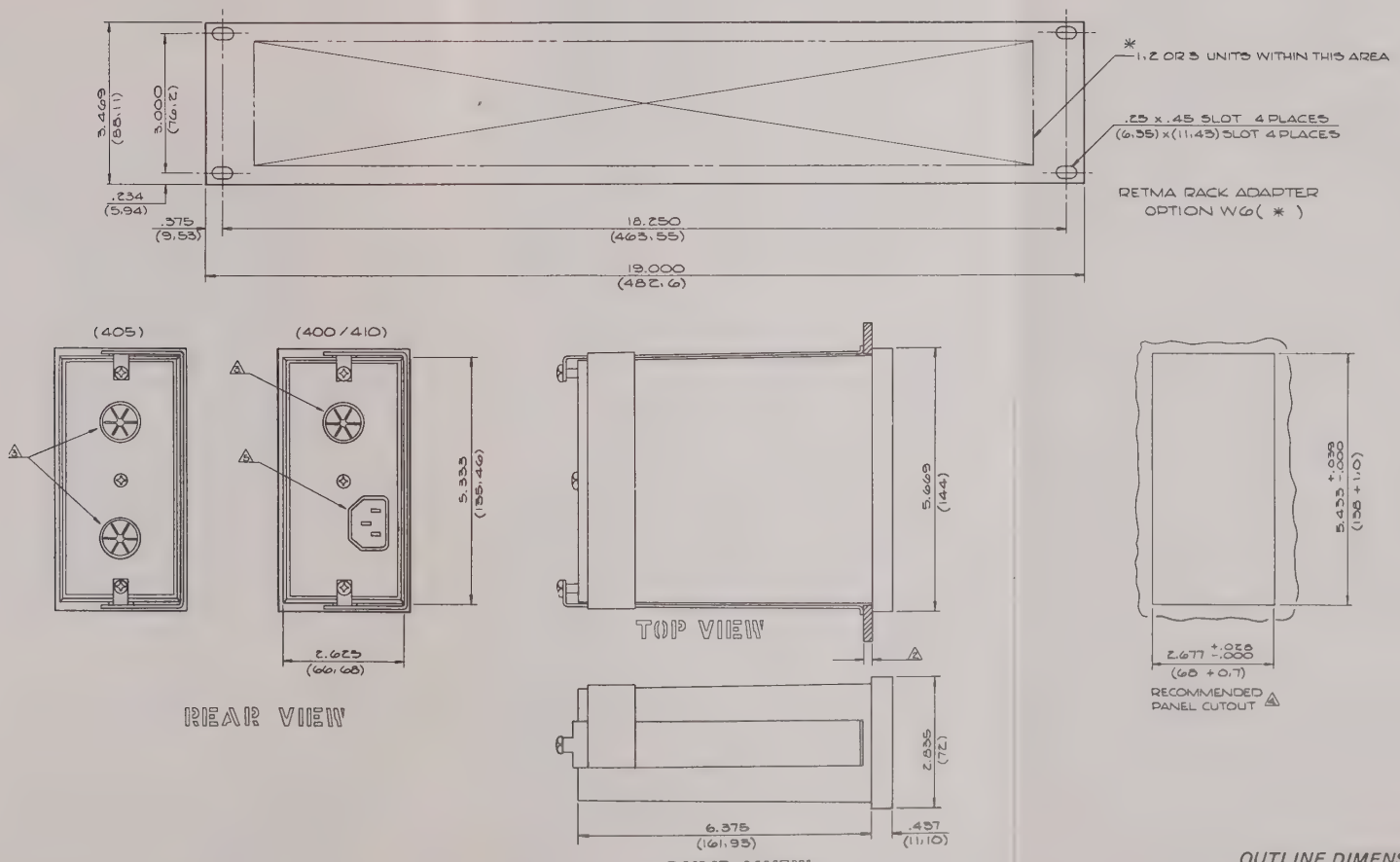
RTD SWITCH BOARD
ASSEMBLY 409-4100-00



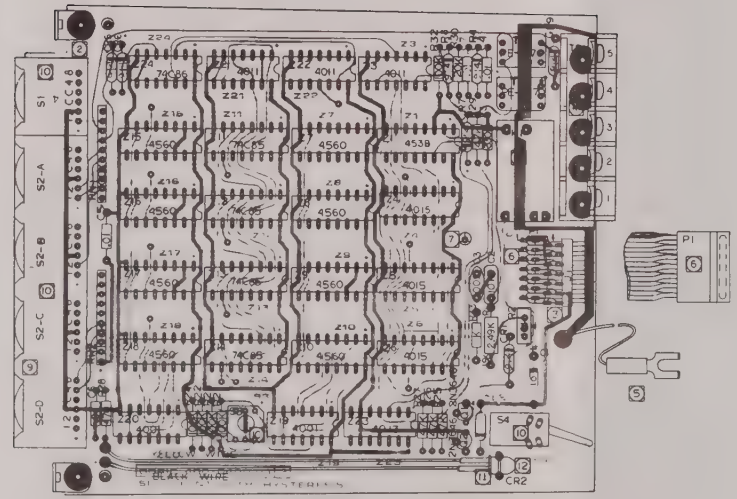
NOTES:

1. □ INDICATES SWITCH BOARD A
2. ○ INDICATES SWITCH BOARD B

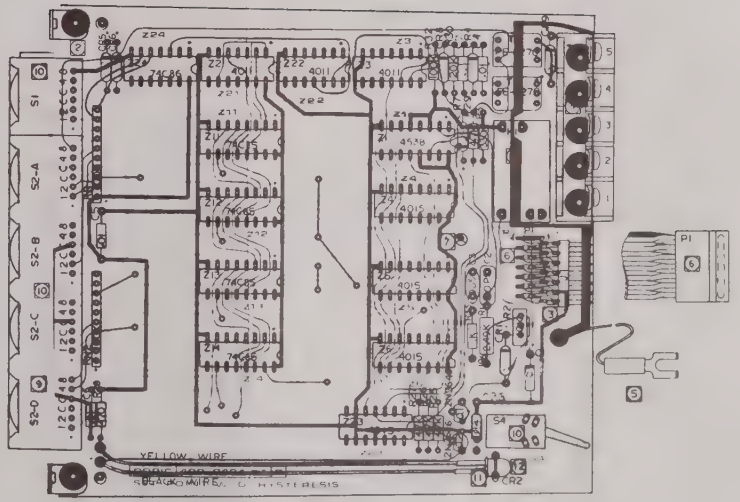
RTD SWITCH BOARD
SCHEMATIC 409-6100-00



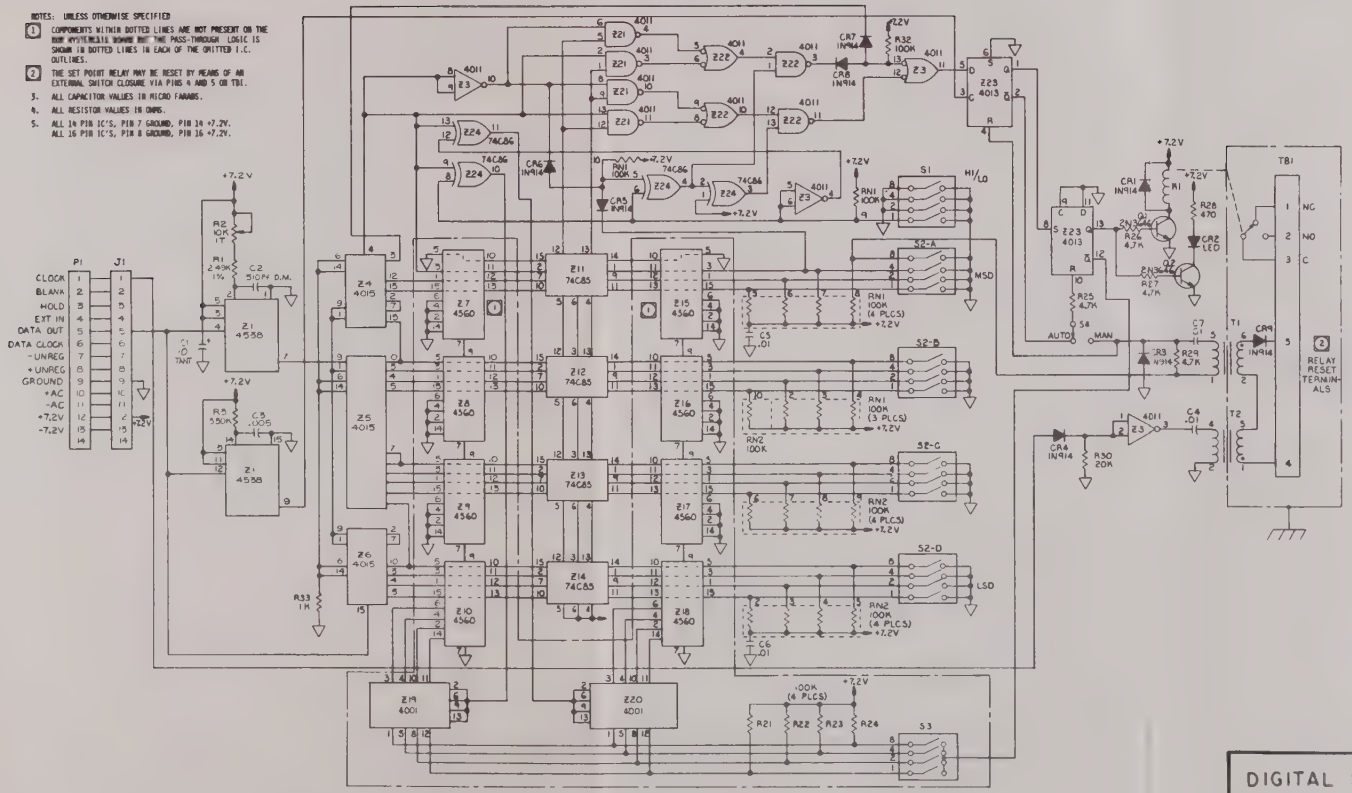
OUTLINE DIMENSIONAL DRAWING 000-7840-00



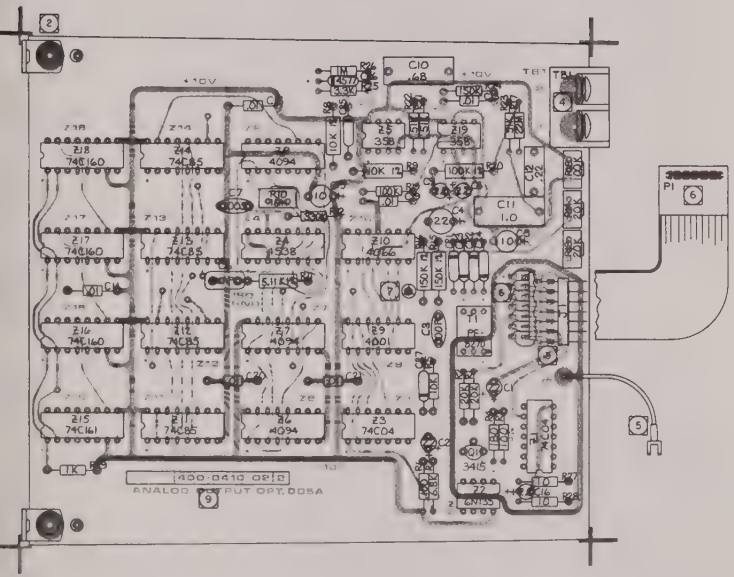
ASSEMBLY –
SET POINT WITH
HYSTERESIS
400-4400-03



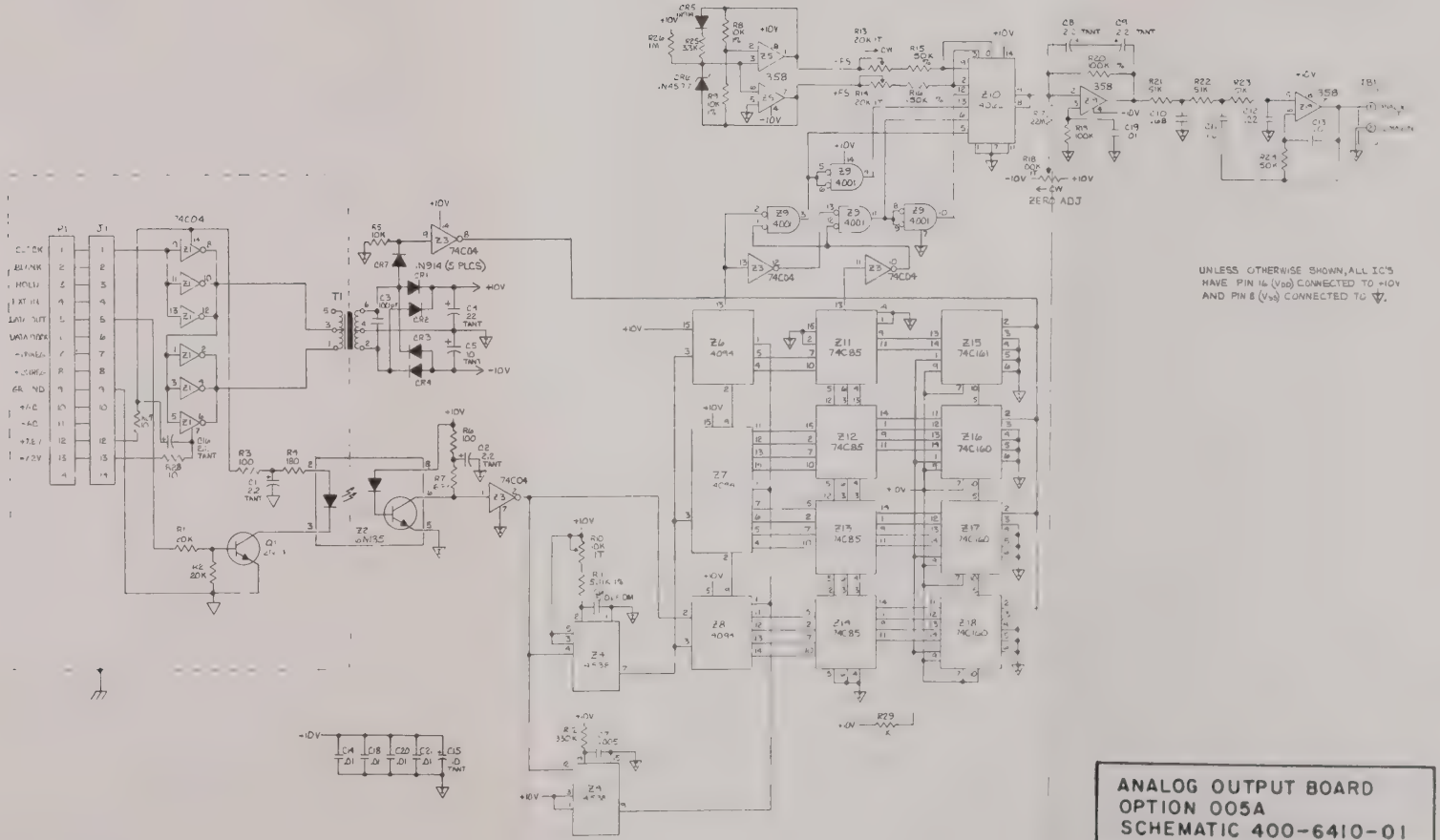
ASSEMBLY –
SET POINT W/O
HYSTERESIS
400-4401-04

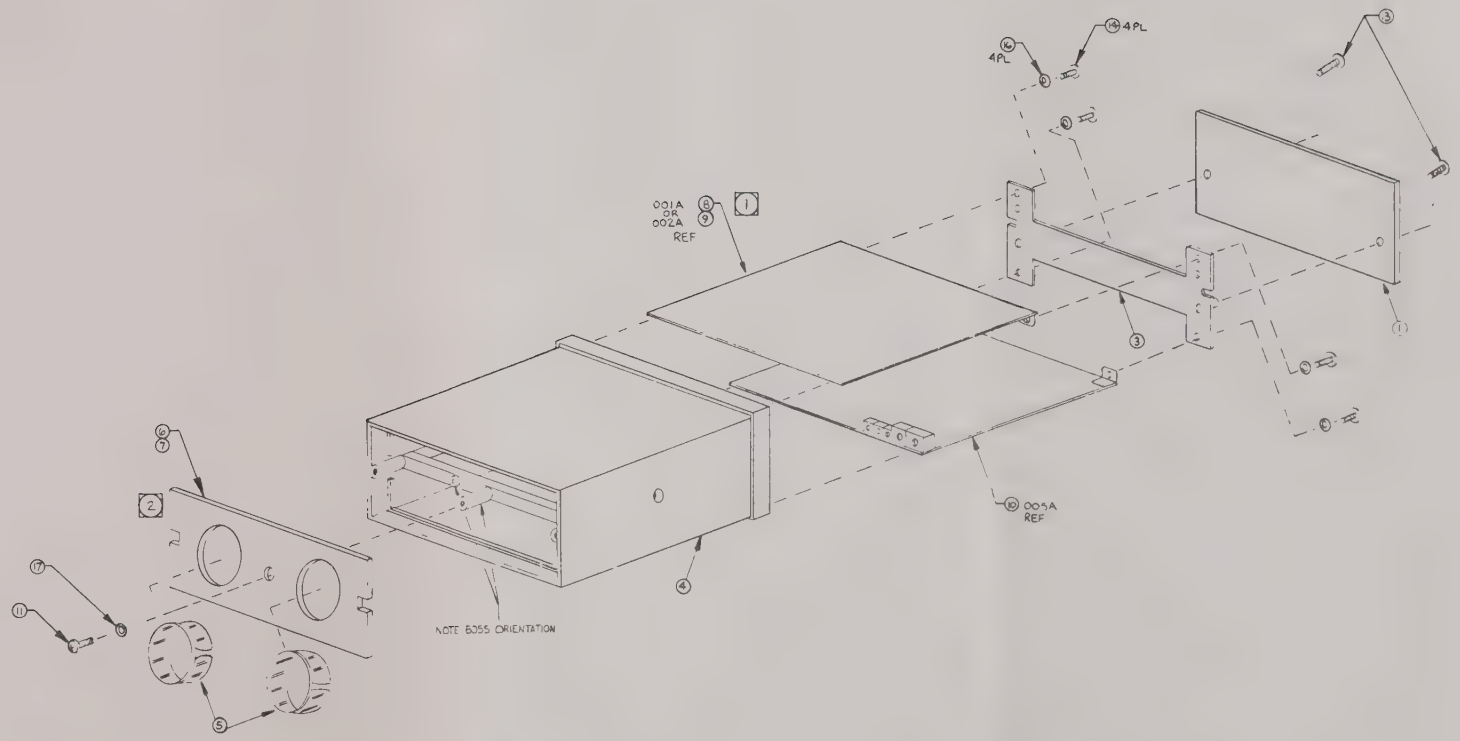


DIGITAL SETPOINT BOARD
OPTIONS 003A/004A
SCHEMATIC 400-6400-02



ASSEMBLY-
ANALOG OUTPUT
400-4410-03 D


UNLESS OTHERWISE SHOWN, ALL IC'S HAVE PIN 16 (V_{DD}) CONNECTED TO +10V AND PIN 8 (V_{SS}) CONNECTED TO ⏚.
ZERO ADJ
ANALOG OUTPUT BOARD
OPTION 005A
SCHEMATIC 400-6410-01



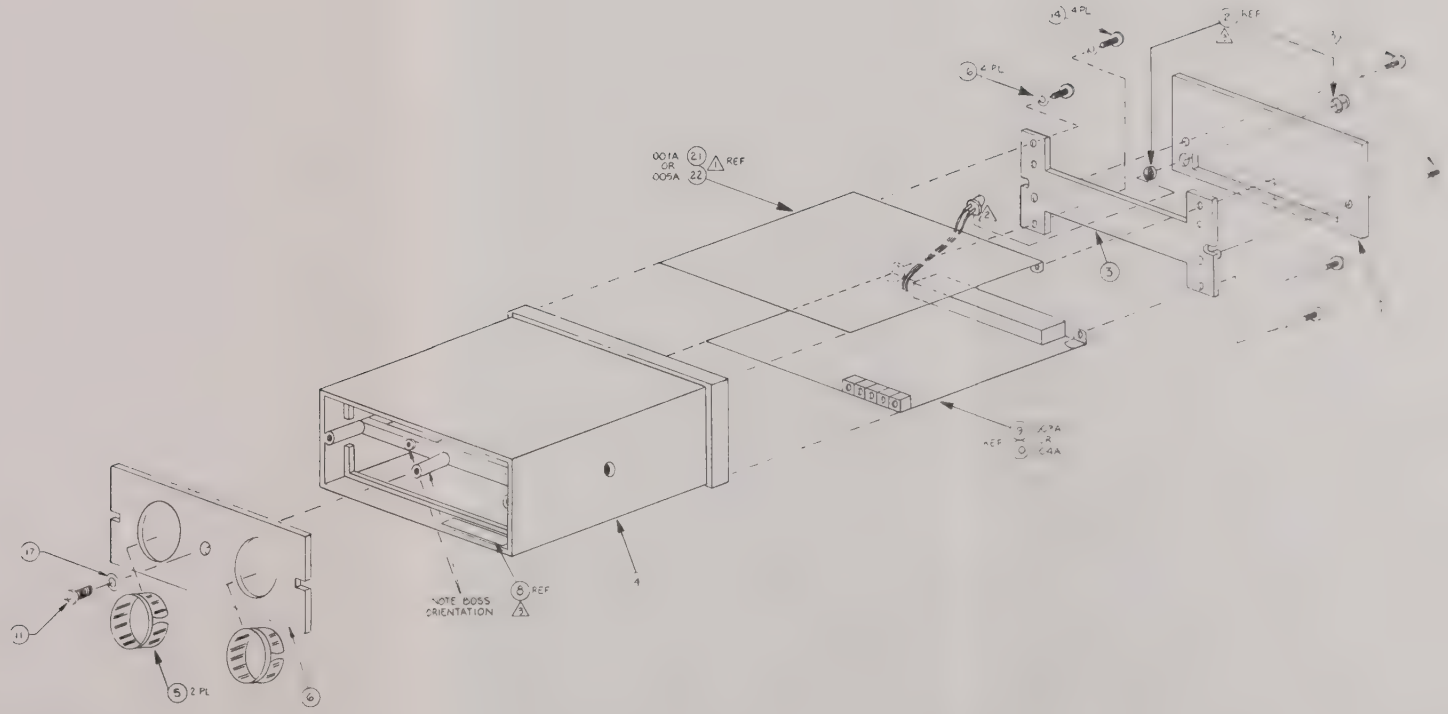
NOTES:

[2] USE ITEM 6 WITH 001A OPTION.
USE ITEM 7 WITH 002A OPTION.

[1] 001 IS MOUNTED COMPONENT SIDE DOWN
002 IS MOUNTED COMPONENTS DE UP

ASSEMBLY

MODEL 411A(-0)
OPTIONS 001A/002A/005A



△3 ITEMS 2 AND 6 ARE SUPPLIED WITH OPTION 005 003A AND 004A.

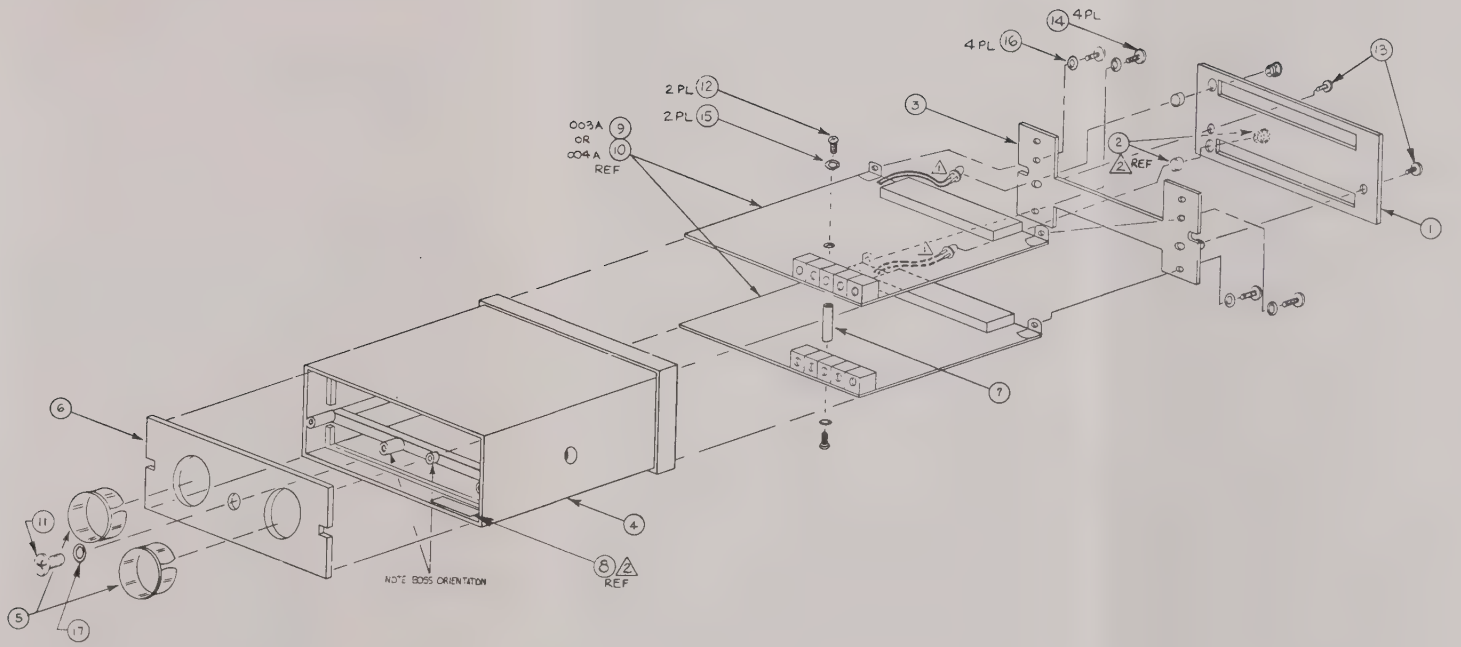
△2 LED ATTACHED TO OPTION 003A OR 004A IS TO BE MOUNTED TO FRONT PANEL USING (2).

△1 001A AND 005A ARE MOUNTED COMPONENT SIDE DOWN.

NOTES

ASSEMBLY

MODEL 411A(-1)
OPTIONS 001A/003A/004A/005A



2 ITEMS 2 AND 8 ARE SUPPLIED WITH OPTION BOARDS 003A OR 004A.

1 LEDS ATTACHED TO OPTION 003A OR 004A ARE TO BE MOUNTED OUTSIDE FRONT PANEL USING 2

NOTES:

ASSEMBLY

MODEL 411A(-2)
OPTIONS 003A/004A

SECTION 7

PARTS LIST

7.0 INTRODUCTION

This section contains the electronic parts list for the Series 400 instruments, subdivided by circuit board assemblies. The list contains a brief description of the part, the quantity per assembly, part number, the manufacturer's name and part or identification number, and recommended spares.

The manufacturer's part number has been omitted on those parts which are easily obtained by using the description. In some cases, the part is available from several manufacturers and when this occurs, only one is listed for convenience.

TITLE	DRWNG. NO.	PAGE
MAIN BOARD (400)	400-4180-XX	7-2
MAIN BOARD (410)	400-4190-XX	7-3
POWER PACK/POT (407)	407-4110-XX	7-5
MULTIRANGE BOARD	400-4450-XX	7-5
POWER PACK (406)	406-4200-XX	7-6
DIN MULTIRANGE BOARD	400-4130-XX	7-7
SWITCH ERROR	400-4420-XX	7-7
SWITCH BOARD	400-4430-XX	7-7
SWITCH BOARD	400-4431-XX	7-7
DATA OUTPUT BOARD	400-4440-XX	7-8
ANALOG MODULE CHART		7-8
SETPOINT BOARD	400-4400-XX	7-9
SETPOINT BOARD	400-4401-XX	7-9
ANALOG OUTPUT BOARD	400-4410-XX	7-10
SERIES 400, HARDWARE		7-11
POWER PACKS, HARDWARE		7-12

MAIN BOARD 400 ASSEMBLY 400-4180

REF. DES.	DESCRIPTION	QTY/ ASSY.	P/N	MFR	MFR'S P/N	REC SPARES
C1, C2, C3	Cap, Disc, .005 @ 1KV	3	900-085-03	Sprague	5GA	
C4-C6	Cap, Elctlt, 390 @ 15V	3	910-390-15	Sprague	672D	1
C7, C8	Cap, Tant, 10 @ 35V	2	916-010-35	Sprague	196D	
C9 C11	Cap, Tant, 2.2 @ 35V	3	916-033-37	Sprague	196D	
C12, C13, C22	Cap, Disc, 100PF @ 1KV	3	901-011-01	Sprague	5GA	
C14	Cap, Polyc, .22 @ 100V	1	911-032-24	Sprague	BA2B	
C15	Cap, Polyc, 2 @ 100V	1	911-032-05	Sprague	BA2B	
C16	Cap, Disc 33 PF @ 1KV	1	901-013-30	Sprague	5GA	
C17, C25, C26	Cap, Disc, .01 @50V	3	900-021-07	Sprague	5GA	
C18	Cap, Disc, 100PF	1	915-031-01	Sprague	DM15	
C20, C21	Cap, Disc, .02 @ 500V	2	900-082-02	Sprague	5GA	
C23	Cap, Mica, 3PF	1	915-030-30	Sprague	DM15	
C24	Cap, Mica, 220PF	1	915-032-21	Sprague	DM15	
C27, C28	Cap, Disc, .1@ 50V	2	900-021-02		Z5U	
CR1	Diode, 6.4V Zener	1	961-457-70	Siemens	1N4577	
DS1-DS4	Display, 7-segment Led	4	968-086-00	Litronix	DL-3405	
J3	IC Socket, 24 DIP	1	992-010-70	Augat	324-AG38D	
P1	Housing, AC Receptacle	1	400-2490-01	Doric		
P1	Ground Pin, AC Receptacle	1	400-2500-01	Doric		
P1	Power Pin, AC Receptacle	2	400-2510-01	Doric		
P2	Connector, PC7M	1	973-380-00	Berg	65625-114	
Q1	Transistor, PNPA152	1	964-040-55	Motorola	MPS U55	1
Q2	Transistor, NPNA152	1	964-040-05	Motorola	MPS U05	1
Q3	Transistor, Selected	1	220-7200-01	Sprague	2N3393	1
Q4, Q5, Q8	Transistor, PNPA	3	962-425-00	National	2N4250	1
Q6, Q7	FET, N-Channel	2	100-722-02	Teledyne	U1742C	1
Q9-Q15	Transistor, NPNA/DR492	7	964-040-03	Motorola	MPSA13	1
Q16	Transistor, NPNA	1	964-040-97	Texas Inst.	TIS97	1
R1, R2	Res, 1/4W 5% 10	2	940-001-00	Corning	FP ¼-10R-5%	
R3, R9	Res, 1/4W 5% 4.7	2	942-204-79	Allen Bradley	RCR07	
R4, R8, R37	Res, 1/4W 5% 1K	3	942-201-02	Allen Bradley	RCR07	
R5, R7	Res, 1/4W 5% 4.7K	2	942-204-72	Allen Bradley	RCR07	
R6, R21	Res, 1/4W 5% 1M	2	942-201-05	Allen Bradley	RCR07	
R10, R11	Res, 10K, 0.1%	2	922-410-02	Dale	RN60C	
R12	Res, 3.65K, 1%	1	920-436-51	Dale	RN60C	
R13	Pot, 1K Cermet	1	960-011-25	Beckman	72XL	1
R14	Pot, 200K Cermet	1	960-012-09	Beckman	89P	1
R15	Res, 2W, 5% 10K	1	942-501-03	Allen Bradley	RCR07	
R16, R31	Res, 1/4W 5% 220K	2	942-202-24	Allen Bradley		
R17	Res, 1/4W 5% 22	1	942-202-20	Allen Bradley		
R18, R32	Res, 1/4W 5% 2.2M	2	942-202-25	Allen Bradley	RCR07	
R19, R22	Pot, 100K Cermet	2	960-011-18	Beckman	72XL	1
R20	Res, 1K, 1%	1	920-410-01	Dale	RN60C	
R23	Res, 56.2K, 1%	1	920-456-22	Dale	RN60C	
R24, R34 R36, R42 R43	Res, 1/4W 5% 100K	5	942-201-04	Allen Bradley	RCR07	
R25	Res, 1.96M, 1%	1	921-419-64	Dale	HMF-1/4, T-2	
R29	Pot, 10K Cermet	1	960-011-16	Beckman	72XL	1
R30	Res, 1/4W 5% 22K	1	942-202-23	Allen Bradley	RCR07	
R33	Res, 953K, 1%	1	921-495-33	Dale	RN65C	
R35	Res, 1/4W 5% 100	1	942-201-01	Allen Bradley	RCR07	
R38	Pot, 2K Cermet	1	960-012-08	Beckman	72XL	1
R39	Res, 1/4W 1% 10.4K	1	920-410-42	Dale	RN60C	
R40	Res, 1/4W 5% 15M	1	942-201-56	Allen Bradley	RCR07	
R41	Res, 1/4W 5% 4.7M	1	942-204-75	Allen Bradley	RCR07	
R44	Pot, 50K Cermet	1	960-015-04	Beckman	89P	1

MAIN BOARD 400 ASSEMBLY 400-4180 (Continued)

REF. DES.	DESCRIPTION	QTY/ ASSY.	P/N	MFR	MFR'S P/N	REC SPARES
R45	Pot, 100K Cermet	1	960-011-09	Beckman	89P	1
R46, R47	Res, 1/4W 5% 10K	2	942-201-03	Allen Bradley	RCR07	
S2	Switch, 6-pole DIP	1	969-050-00	Grayhill	76YY2828S	1
T1	Transformer, Power	1	400-7040-00	Doric		1
TB1	Terminal Strip	1	973-010-37	Reed Dev.	6PCR04-002	
Z1, Z3	IC, Graded 4016	2	000-7700-00	Doric		
Z2, Z4	IC, Op. Amp.	2	965-590-01	National	308	
Z5, Z6	IC, Op. Amp.	2	965-592-01	National	301A	1
Z7	IC, Inv, NOR, NAND	1	965-618-00	Motorola	4572	1
Z8	IC, Op. Amp, Dual	1	965-617-00	National	358	1
Z9	IC, PMOS LSI	1	000-7500-00*	Doric	*or 000-7501-00	1
Z10	IC, Hex Driver	1	965-619-00	National	75494	1
Z11	Resistor Network 39Ω	1	950-003-90			
Z12	Rectifier Bridge	1	966-002-26	Gen. Inst.	WL005M	1
	IC Socket, 40 DIP	1	992-010-18	Circuit Assy.	405-105D	
	Cable, Flat	1	993-100-00	Augat	340-AG38D	

MAIN BOARD 410 ASSEMBLY 400-4190

REF. DES.	DESCRIPTION	QTY/ ASSY.	P/N	MFR	MFR'S P/N	REC SPARES
C1, C2, C3	Cap, Disc, .005 @ 1KV	3	900-085-03	Sprague	5GA	
C4-C6	Cap, Elctlt, 390 @ 15V	3	910-390-15	Sprague	672D	1
C7, C8	Cap, Tant, 10 @ 35V	2	916-010-35	Sprague	196D	
C9-C11	Cap, Tant, 2.2 @ 35V	3	916-033-37	Sprague	196D	
C12, C13	Cap, Disc, 100PF @ 1KV	2	901-011-01	Sprague	5GA	
C14	Cap, Polyc, .22 @ 100V	1	911-032-24	Sprague	BA2B	
C15	Cap, Polyc, 2 @ 100V	1	911-032-05	Sprague	BA2B	
C16	Cap, Mica, 3PF	1	915-030-30	Sprague	DM15	
C17, C25, C26,	Cap, Disc, .01 @50V	3	900-021-07	Sprague		
C18	Cap, Disc, 100PF	1	915-031-01	Sprague	DM15	
C20, C21	Cap, Disc, .02 @ 500V	2	900-082-02	Sprague	5GA	
C24	Cap, Mica, 220PF	1	915-032-21	Sprague	DM15	
C27, C28	Cap, Disc, .1 @50V	2	900-021-02		Z5U	
CR1	Diode, 6.4V, Zener	1	961-457-70	Siemens	1N4577	
DS1-DS5	Display, 7-Segment	5	968-086-00	Litronix	DL-3405	
J3	IC Sockét, 24 DIP	1	992-010-70	Augat	324-AG38D	
P1	Housing, AC Receptacle	1	400-2490-01	Doric		
P1	Ground Pin, AC Receptacle	1	400-2500-01	Doric		
P1	Power Pin, AC Receptacle	2	400-2510-01	Doric		
P2	Connector, PC7M	1	973-380-00	Berg	65625-114	
Q1	Transistor, PNPA152	1	964-040-55	Motorola	MPSU55	1
Q2	Transistor, NPNA152	1	964-040-05	Motorola	MPSU05	1
Q3	Transistor, Selected	1	220 7200 01	Sprague	2N3393	1
Q4, Q5, Q8	Transistor, PNPA	3	962 425 00	National	2N4250	1
Q6, Q7	FET, N-Channel	2	100 722 02	Teledyne	U1742C	1
Q9-Q15	Transistor, NPNA/DR492	7	964 040 03	Motorola	MPSA13	1
Q16	Transistor, NPNA	1	964-040-97	Texas Inst.	TIS97	1
R1, R2	Res, 1/4W 5% 10	2	940 001-00	Corning	FP ¼-10R-5%	
R3, R9	Res, 1/4W 5% 4.7	2	942 204 79	Allen Bradley	RCR07	
R4-R8-R37	Res, 1/4W 5% 1K	3	942 201 02	Allen Bradley	RCR07	

MAIN BOARD 410 ASSEMBLY 400-4190 (Continued)

REF. DES	DESCRIPTION	QTY/ ASSY.	P/N	MFR	MFR'S P/N	REC SPARES
R5, R7	Res, 1/4W 5%4 7K	2	942-204-72	Allen Bradley	RCR07	
R6, R21	Res, 1/4W 5% 1M	2	942-201-05	Allen Bradley	RCR07	
R10, R11	Res, WW, 10K	2	934-211-75	Elliot	Type 31	
R12	Res, 3.65K, 1%	1	920-436-51	Dale	RN60C	
R13	Pot 1K Cermet	1	960-011-25	Beckman	72XL	1
R14	Pot, 100K Cermet	1	960-011-09	Beckman	89P	1
R15	Res, 2W, 5% 10K	1	942-501-03	Allen Bradley	RCR07	
R16, R31	Res, 1/4W 5% 220K	2	942-202-24	Allen Bradley	RCR07	
R17	Res, 1/4W 5% 22	1	942-202-20	Allen Bradley	RCR07	
R18, R32	Res, 1/4W 5% 2.2M	2	942-202-25	Allen Bradley	RCR07	
R19, R22	Pot, 100K Cermet	2	960-011-18	Beckman	72XL	1
R20	Res, WW, 1K	1	934-211-74	Elliot	Type 31	
R23	Res, WW 56.25K	1	937-201-14	Elliot	Type 31	
R24, R34, R42, R43	Res, 1/4W 5% 100K	4	942-201-04	Allen Bradley	RCR07	
R25	Res, 2.02M 1%	1	921-420-24	Dale	HMF-1/4, T2	
R26	Res, 1/4W 5% 22M	1	942-202-26	Allen Bradley	RCR07	
R27	Res, 1/4W 5% 10M	1	942-201-06	Allen Bradley	RCR07	
R29	Pot, 10K Cermet	1	960-011-16	Beckman	72XL	1
R30	Res, 1/4W 5% 22K	1	942-202-23	Allen Bradley	RCR07	
R33	Res, WW, 990.75K	1	937-201-13	Elliot	Type 31	
R35	Res, 1/4W 5% 100	1	942-201-01	Allen Bradley	RCR07	
R36	Res, 1/4W 5% 390K	1	942-203-94	Allen Bradley	RCR07	
R38	Pot, 2K Cermet	1	960-012-08	Beckman	72XL	1
R39	Res, 1/4W 1% 10.4K	1	920-410-42	Dale	RN60C	
R40	Res, 1/4W 5% 15M	1	942-201-56	Allen Bradley	RCR07	
R41	Res, 1/4W 5% 4.7M	1	942-204-75	Allen Bradley	RCR07	
R44	Pot, 50K Cermet	1	960-015-04	Beckman	89P	1
R45	Pot, 25K Cermet	1	960-012-53	Beckman	89P	1
R46, R47	Res, 1/4W 5% 10K	2	942-201-03	Allen Bradley	RCR07	
S2	Switch, 6 Pole DIP	1	969-050-00	Grayhill	76YY2828S	1
T1	Transformer, Power	1	400-7040-01	Doric		1
TB1	Terminal Strip	1	973-010-37	Reed Dev.	6PCR04-002	1
Z2	IC, Op. Amp	1	965-607-00	PMI	OP-07CP	1
Z1, Z3	IC, Graded 4016	2	000-7700-00	Doric	Special	
Z4, Z5	IC, Op. Amp.	2	965-616-00	National	356	1
Z6	IC, Op. Amp.	1	965-592-01	National	301A	1
Z7	IC, Inv, NOR, NAND	1	965-618-00	Motorola	4572	1
Z8	IC, Op. Amp., Dual	1	965-617-00	National	358	1
Z9	IC, PMOS LSI	1	000-7500-00 or 000-7501-00	Doric	Special	1
Z10	IC, Hex Driver	1	965-619-00	National	75494	1
Z11	Resistor Network 39Ω	1	950-003-90			
Z12	Rectifier Bridge	1	966-002-26	Gen. Inst.	WL005M	1
	IC Socket, 40 DIP	1	992-010-18	Augat	340-AG38D	
	Cable, Flat	1	993-100-00	Ansley	FSN-23A-18	

POWER PACK POTENTIOMETER, ASSEMBLY 407-4100

REF. DES.	DESCRIPTION	QTY/ ASSY.	P/N	MFR	MFR'S P/N	REC SPARES
C1, C2	Cap, Elctlt. 390 @15V	2	910-390-15	Sprague	672D	1
C3	Cap, Elctlt. 270 @40V	1	910-270-40	Sprague	672D	1
C4	Cap, Disc. .01 @50V	1	900-021-07		Z5U	
C5-C7	Cap, Tant 47 @20V	3	916-471-20	Sprague	196D	
CR1	Rectifier Bridge	1	966-002-26	Gen. Inst.	WL005M	1
CR2-CR7	Rectifier, 100V	6	966-002-00		IN4002	2
CR8	LED, Red	1	968-010-10	Dialco	550-01-03	1
CR9	Diode, 7.5V	1	961-523-62	Diodes, Inc.	1N5236B	1
Q1	Transistor, NPNSH106	1	962-364-60	Motorola	2N3646	1
Q2, Q6	Transistor, PNPA	1	962-425-00	National	2N4250	1
Q3	Transistor, NPNA98-5	2	962-339-30	Sprague	2N3393	1
Q4	Transistor, PNPA152	1	964-040-55	Motorola	MPSU55	1
Q5	Transistor, NPNA98-5		962-339-30	Sprague	2N3393	
R1	Res, 5.11K, 1%	1	920-451-11	Dale	CMF60C	
R2	Res, 6.34K, 1%	1	920-463-41	Dale	CMF60C	
R3	Pot, 2K Cermet	1	960-012-08	Beckman	72XL	1
R4	Res, 1/4W 5% 1M	2	942-201-05	Allen Bradley		
R5	Res, 1/4W 5% 4.7M	2	942-204-75	Allen Bradley	RCR07	
R6	Res, 1/4W 5% 30K	1	942-203-03	Allen Bradley	RCR07	
R7	Res, 1/4W 5% 680	1	942-206-81	Allen Bradley	RCR07	
R8	Res, 1K, 1%	1	920-410-01	Dale	CMF60C	
R9	Res, 2.49K	1	920-424-91	Dale	CMF60C	
R10	Pot, 10K WW	1	960-011-21	Amp	4201B103	1
R11	Res, 5.49K	1	920-454-91	Dale	CMF60C	
R12/SW2	Pot/Switch, 100K	1	960-011-20	Allen Bradley	SERIES 70	1
R13	Res, 1/4W 5% 4.7M		942-204-75	Allen Bradley	RCR07	
R14	Res, 490, 1%	1	920-349-00	Dale	CMF60C	
R15	Res, 10, 1%	1	920-310-09	Dale	CMF60C	
R16	Res, 20K, 1%	2	920-420-02	Dale	CMF60C	
R17	Res, 499, 1%	1	920-449-90	Dale	CMF60C	
R18	Res, 20K, 1%		920-420-02	Dale	CMF60C	
R19	Res, 1/4W 5% 100K	2	942-201-04	Allen Bradley		
R20	Pot, 100K Cermet	1	960-011-18	Beckman		
R21	Res, 1/4W 5% 680K	1	942-206-84	Allen Bradley		
R22, R26, R28	Res, 1/4W 5% 1K	3	942-201-02	Allen Bradley		
R23	Res, 1/4W 5% 10K	1	942-201-03	Allen Bradley		
R24	Res, 1/4W 5% 100K		942-201-04	Allen Bradley		
R25	Res, 1/4W 5% 330	1	942-203-31	Allen Bradley		
R27	Res, 1/4W 5% 1M		942-201-05	Allen Bradley		
R29	Res, ¼W 5% 2.7	1	942-202-79			
SW1	Switch, Rocker	1	969-020-00	C & K	7101J-1V5B	1
SW2	See R12					
Z1	IC, Quad Op. Amp.	1	965-599-00	National	324	1
Z2	IC, Hex Inverter	1	965-587-05	National	4069	1
Z3	Regulator	1	965-644-00	Fairchild	78MGU1	1
	Battery Assembly	1	407-4200-02	Doric		1

MULTIRANGE BOARD, ASSEMBLY 400-4450

REF. DES.	DESCRIPTION	QTY ASSY.	P/N	MFR	MFR'S P/N	REC SPARES
C1	Cap, Disc 220PF @ 1KV	1	901-012-21	Sprague	5GA	
CR1-CR11	Diode	11	961-091-40	Teledyne	1N4148	2
R1	Res, WW 20K	1	934-212-03	Elliot	Type 31	
R2	Pot, 200 Cermet	3	960-012-04	Beckman	72XL	1
R3	Res, WW, 25.834K	1	934-202-06	Elliot	Type 31	
R4	Pot, 200 Cermet		960-012-04	Beckman	72XL	
R5	Res, WW, 25.696K	1	934-202-05	Elliot	Type 31	

MULTIRANGE BOARD, ASSEMBLY 400-4450 (Continued)

REF. DES.	DESCRIPTION	QTY/ ASSY.	P/N	MFR	MFR'S P/N	REC SPARES
R6	Pot, 200 Cermet		960-012-04	Beckman	72XL	
R7	Res, WW, 181 972K	1	934 202-02	Elliot	Type 31	
R8	Pot, 2K Cermet	3	960 012 08	Beckman	72XL	1
R9	Res, WW, 180.637K	1	934 202-01	Elliot	Type 31	
R10	Pot, 2K Cermet		960-012-08	Beckman	72XL	
R11	Res, WW, 187 165K	1	934-202-03	Elliot	Type 31	
R12	Pot, 2K Cermet		960-012-08	Beckman	72XL	
R13	Res, 1/4W 10% 100M	4	943-201-07	Allen Bradley	RCR07	
R14	Res, 1/4W 5% 15M	1	942-201-56	Allen Bradley		
R15	Res, 1/4W 10% 100M		943-201-07	Allen Bradley		
R16	Res, 13K, 1%	1	920-413-02	Dale	CMF60C	
R17	Res, 20K, 1%	1	920-420-02	Dale	CMF60C	
R18	Res, 117K, 1%	1	920-411-73	Dale	CMF60C	
R19	Res, 1.30M, 1%	1	922-413-04	Dale	HMF-1/8, T2	
R20	Res, 1/4W 5% 22M	1	942-202-26	Allen Bradley	RCR07	
R21	Pot, 100K Cermet	1	960-011-18	Beckman	72XL	
R22, R23	Res, 1/4W 10% 100M		943-201-07	Allen Bradley		
S1-S6	Switch	1	969-010-21	Centralab	6PB-4P-IL	1
	Engraved Button Set	1	400-2290-00	Doric		
	Cable 3 inch	1	993 100 10	Ansley		

POWER PACK 406, ASSEMBLY 406-4200

REF DES.	DESCRIPTION	QTY/ ASSY.	P/N	MFR	MFR'S P/N	REC SPARES
C1, C2	Cap, Elct 390 @ 15V	2	910-390-15	Sprague	672D	1
C3	Cap, Elct 270 @ 40V	1	910-270-40	Sprague	672D	1
C4	Cap, Disc .01 @ 50V	1	900-021-07	Sprague	5GA	
C5-C7	Cap, Tant 47 @ 20V	3	916-471-20	Sprague	196D	
CR1	Rectifier Bridge	1	966-002-26	Gen. Inst.	WL005M	1
CR2-CR7	Rectifier, 100V	6	966-002-00		1N4002	2
CR8	LED, Red.	1	968-010-10	Dialco	550-01-03	1
CR9	Diode (7.5V)	1	961-523-62	Fairchild	1N5236B	1
Q1	Transistor	1	962-364-60	Motorola	2N3646	1
Q2, Q6	Transistor	2	962-425-00	National	2N4250	1
Q3	Transistor, NPNA98-5	2	962-339-30	Sprague	2N3393	1
Q4	Transistor, PNPA152	1	964-040-55	Motorola	MPSU55	1
Q5	Transistor, NPNA98-5		962-339-30	Sprague	2N3393	
R1	Res, 5.11K, 1%	1	920-451-11	Dale	CMF60C	
R2	Res, 6.34K, 1%	1	920-463-41	Dale	CMF60C	
R3	Pot, 2K Cermet	1	960-012-08	Beckman	72XL	1
R4	Res, 1/4W 5% 1M	1	942-201-05	Allen Bradley	RCR07	
R5	Res, 1/4W 5% 4.7M	1	942-204-75	Allen Bradley	RCR07	
R6	Res, 1/4W 5% 30K	1	942-203-03	Allen Bradley	RCR07	
R7	Res, 1/4W 5% 680	1	942-206-81	Allen Bradley	RCR07	
R19	Res, 1/4W 5% 100K	2	942-201-04	Allen Bradley	RCR07	
R20	Pot, 100K Cermet	1	960-011-18	Beckman	72XL	1
R21	Res, 1/4W 5% 680K	1	942-206-84	Allen Bradley	RCR07	
R22, R26, R28	Res, 1/4W 5% 1K	3	942-201-02	Allen Bradley	RCR07	
R23	Res, 1/4W 5% 10K	1	942-201-03	Allen Bradley	RCR07	
R24	Res, 1/4W 5% 100K		942-201-04	Allen Bradley	RCR07	
R25	Res, 1/4W 5% 330	1	942-203-31	Allen Bradley	RCR07	
R27	Res, 1/4W 5% 2.7	1	942-202-79	Allen Bradley	RCR07	
SW1	Rocker Switch	1	969-020-00	C & K	7101J-1V58	1
Z1	IC, Quad. Op. Amp.	1	965-599-00	National	324	1
Z2	IC, Hex Inverter	1	965-587-05	National	4069	1
Z3	Regulator	1	965-644-00	Fairchild	78MGU1	1
	Battery Assembly	1	407-4200-02	Doric		1

DIN MULTIRANGE BOARD, ASSEMBLY 400-4130

RES. DES.	DESCRIPTION	QTY/ ASSY.	P/N	MFR	MFR'S P/N	REC SPARES
CR1-CR11	Diode	11	961-091-40	Teledyne	1N4148	2
R1	Pot, 200 Cermet	5	960-012-04	Beckman	72XL	1
R2	Res, WW 19.489K	1	934-216-69	Elliot	Type 31	
R3	Pot, 200 Cermet		960-012-04	Beckman	72XL	
R4	Res, WW 25.834K	1	934 202-06	Elliot	Type 31	
R5	Pot, 200 Cermet		960-012-04	Beckman	72XL	
R6	Res, WW 25.486K	1	934-216-70	Elliot	Type 31	
R7	Pot, 200 Cermet		960-012-04	Beckman	72XL	
R8	Res, WW 16.826K	1	934-216-68	Elliot	Type 31	
R9	Pot, 10 Cermet	1	960-011-19	Beckman	72XL	1
R10	Res, WW 857.3	1	937-201-19	Elliot	Type 31	
R11	Pot, 200 Cermet		960-012-04	Beckman	72XL	
R12	Res, WW 31K	1	937-201-18	Elliot	Type 31	
R13	Res, WW 71.61K	1	937-201-20	Elliot	Type 31	
R14	Res, WW 71.71K	1	937-201-21	Elliot	Type 31	
R15	Pot, 50K Cermet	1	960-015-08	Beckman	72XL	1
R16, R17	Pot, 100K Cermet	2	960-011-18	Beckman	72XL	1
R18	Res, 1/4W 10% 100M	4	943-201-07	Allen Bradley	RCR07	
R19	Res, 1/4W 5% 15M	1	942-201-56	Allen Bradley	RCR07	
R20	Res, 1/4W 10% 100M		943-201-07	Allen Bradley	RCR07	
R21	Res, 13K, 1%	1	920-413-02	Dale	CMF60C	
R22	Res, 20K, 1%	1	920-420-02	Dale	CMF60C	
R23	Res, 117K, 1%	1	920-411-73	Dale	CMF60C	
R24	Res, 1.30M 1%	1	922-413-04	Dale	HMF-1/8, T2	
R25	Res, 1/4W 10% 100M		943-201-07	Allen Bradley	RCR07	
R26	Res, 1/4W 5% 22M	2	942-202-26	Allen Bradley	RCR07	
R27	Res, 1.2605M, 0.1%	1	922-412-64	Dale	HMF-1/8, T2	
R28	Res, 1/4W 5% 22M		942-202-26	Allen Bradley	RCR07	
R29	Res, 1/4W 10% 100M		943-201-07	Allen Bradley	RCR07	
S1-S6	Switch	1	969-010-24	Centralab	PB15	1
	Engraved Button Set	1	400-2291-00	Doric	Special	
	Cable, 3 inch	1	993 100 10	Ansley		

SWITCH ERROR INDICATOR, ASSEMBLY 400-4420

REF. DES.	DESCRIPTION	QTY/ ASSY.	P/N	MFR	MFR'S P/N	REC SPARES
Q1	Transistor, PNP	1	962 425-00	National	2N4250	1
Q2	Transistor, NPN	1	962 339-30	Sprague	2N3393	1
R1 R2	Res, 1/4W 5% 10K	2	942-201-03	Allen Bradley	RCR07	
R3	Res, 1/4W 5% 6.8K	1	942 206-82	Allen Bradley	RCR07	
TB1	Terminal Strip	1	973-010-32	Reed Dev.	6PCR02-002	
	Cable Assy, I/O	1	993-300-02	Doric	Special	

SWITCH BOARD, ASSEMBLY 400-4430, 400-4431

REF. DES.	DESCRIPTION	QTY/ ASSY.	P/N	MFR	MFR'S P/N	REC SPARES
R1 R5	Res, 1/4W 5% 10K	5	942 201-03	Allen Bradley	RCR07	
S1 S5	Switch	1	969 010 23	Centralab	PB15	1
	Terminal Strip	1	973 010 34	Reed Dev	6RCR12 002	
4431 ONLY						
CR1-CR10	Rectifier, 100V	10	966-002-00		1N4002	2

DATA OUTPUT BOARD, ASSEMBLY 400-4440

REF DES	DESCRIPTION	QTY	P/N	MFR	MFR'S P/N	REC SPARES
C2, C3, C7, C13, C14	Cap, Tant, 2.2 @ 35V	5	916-220-04	Sprague	196D	
C4	Cap, Disc, 100 PF @ 1KV	3	901-011-01	Sprague	5GA	
C5	Cap, Tant, 47 @ 20V	1	916-471-20	Sprague	196D	
C6	Cap, Disc .01 @ 500V	1	900-021-04	Sprague	5GAS10	
C8	Cap, Mica, 510 PF	1	915-035-11	Sprague	DM15	
C9	Cap, Disc .005 @ 1KV	1	900-085-03	Sprague	5GA	
C10	Cap, Tant, 10 @ 35V	1	916-010-35	Sprague	196D	
C11, C12	Cap, Disc, 100 PF @ 1KV		901-011-01	Sprague	5GA	
CR1	Diode, 1N457A	1	961-045-70	Teledyne		
CR2-CR5	Diode, 1N914	4	961-091-40	Teledyne		
CR6	Diode, 1N751A	1	961-075-11	Teledyne		
J1	Connector, Cable 14F	1	973-390-00	Berg	65043-030	
Q1	Transistor, 2N3646	1	962-364-60	Motorola	NPNSH106	
Q2	Transistor, 2N3638	1	962-363-80	National	PNPSH105	
Q3	Transistor, 2N3415	1	962-341-50	Motorola	NPNA98-5	
Q4	FET, U1742C	1	100-722-02	Teledyne		
Q5	Transistor, 2N3393	1	962-339-30	Sprague	NPNA98-5	
R1, R2	Res, 1/4 W 5% 100	4	942-201-01	Allen Bradley		
R3, R4, R15	Res, 1/4 W 5% 20K	3	942-202-03	Allen Bradley		
R5	Res, 1/4 W 5% 100		942-201-01	Allen Bradley		
R6	Res, 1/4 W 5% 180	1	942-201-81	Allen Bradley		
R7	Res, 1/4W 5% 47K	1	942-204-73	Allen Bradley		
R8	Res, 1/4 W 5% 1K	1	942-201-02	Allen Bradley		
R9	Res, 1/4 W 5% 100		942-201-01	Allen Bradley		
R10	Res, 1/4 W 5% 6.8K	1	942-206-82	Allen Bradley		
R11	Res, 1/4 W 5% 510	1	942-205-11	Allen Bradley		
R12	Pot, 10K Cermet	1	960-011-16	Beckman	72XL	1
R13	Res, RN60C, 5.11K	1	920-451-11	Dale		
R14	Res, 1/4 W 5% 330K	1	942-203-34	Allen Bradley		
R16-R18	Res, 1/4 W 5% 100K	3	942-201-04	Allen Bradley		
R19, R20	Res, ¼W 5% 10	2	942-201-00			
R21	Res, ¼W 5% 10K	1	942-201-03			
T1	Transformer	1	967-020-10	Pulse Eng.	8270	1
Z1, Z2	IC, Optical Isolator	2	965-570-00	Hewlett-Packard	5082-4350	1
Z3, Z9-Z12	IC, Hex Inverter, CMOS	5	965-587-21	Fairchild	4049	1
Z4	IC, Multi-vibrator	1	965-587-72	Fairchild	4538	1
Z5	IC, 4-2 IN NAND CMOS	1	965-587-02	Motorola	4011	1
Z6-Z8	IC, Dual SR CMOS	3	965-587-03	Motorola	4015	1
Z13	IC, Dual DFF, CMOS	1	965-587-23	Fairchild	4013	1
	Terminal, Female	6	973-395-00	Berg	47712	
	Mating Connector, Data Output	1	973-010-40	SAE	SCC15/DI-2	1
	Hood, Connector	1	973-010-41	Viking	036-0098-002	1
	Key, Connector	1	973-021-05	SAE	057-002-0000	1

ANALOG PROGRAMMING MODULE CHART

PART #	RANGE	PART #	RANGE	PART #	RANGE
400-4530-00	J	400-4540-00	P3	400-4545-01	K3
400-4531-00	K	400-4539-00	P4	400-4546-01	K4
400-4532-00	T	400-4548-00	P5	400-4550-00	K5
400-4533-00	R	400-4549-00	P6	400-4551-00	TF
400-4534-00	S	400-4541-00	I1	400-4552-00	TC
400-4535-01	B	400-4542-00	I2	400-4553-00	C3
400-4536-00	FC	400-4547-01	I3	400-4554-00	C4
400-4537-00	CC	400-4543-00	K1	400-4555-00	2J
400-4538-00	E	400-4544-00	K2	400-4556-00	2T

SETPOINT BOARD (OPTIONS 003A/004A), ASSEMBLIES 400-4400/400-4401

REF DES	DESCRIPTION	QTY 003A	QTY 004A	PIN	MFR	MFR'S PIN	REC SPARES
C1	Cap, Tant, 10 @10V	1	1	916-010-10	Sprague	196D	
C2	Cap, Mica, 510 pF	1	1	915-035-11	Sprague	DM15	
C3	Cap, Disc, .005 @ 1KV	1	1	900-085-03	Sprague	5Ga	
C4—C7	Cap, Disc, .01 @50V	4	4	900-021-07	Sprague	5GA	
CR1	Diode, 1N914	3	3	961-091-40	Teledyne	1N4148	
CR2	LED, Red	1	1	993-300 07			
CR3, CR4	Diode, 1N914			961-091-40	Teledyne	1N4148	
J1	Connector, PC7M	1	1	973-380-00	Berg	65625-114	
K1	Relay	1	1	970-011-01	Am.Zettler	Az530-09-100	1
Q1, Q2	Transistor, 2N3646	2	2	962-364-60	Motorola	NPNSH106	1
R1	Resistor, 2.49K	1	1	920-424-91	Allen Bradley	RN60C	
R2	Potentiometer, 10K	1	1	960-011-16	Beckman	72XL	1
R3	Resistor, ¼W 5% 330K	1	1	942-203-34	Allen Bradley		
RN1, RN2	Resistor Network 100K	2	2	950-010-03			
R21-R24, R32	Resistor, ¼W 5% 100K	1	5	942-201-04	Allen Bradley		
R25—R27	Resistor, ¼W 5% 4.7K	4	4	942-204-72	Allen Bradley		
R28	Resistor, ¼W 5% 470	1	1	942-204-71	Allen Bradley		
R29	Resistor, ¼W 5% 4.7K			942-204-72	Allen Bradley		
R30	Resistor, ¼W 5% 20K	1	1	942-202-03	Allen Bradley		
R33	Resistor, ¼W 5% 1K	1	1	942-201-02			
S1	Switch, Thumbwheel	1	1	969-011-27	EECO	12769	1
S2	Switch, 4-wheel	1	1	200-7020-01	Doric	Special	1
S4	Switch, Toggle	1	1	969-010-73	Singer	T8001	1
S3	Switch	0	1	969-011-28	EECO	2300	1
T1, T2	Transformer	2	2	967-020-10	Pulse	8270	
TB1	Terminal, 5 position	1	1	973-010-68	Reed	6PCR05-002	
Z1	IC, Mono-vibrator	1	1	965-587-72	Fairchild	4538	1
Z3	IC, 4-2 IN NAND	3	3	965-587-02	Motorola	4011	1
Z4—Z6	IC, Dual, CMOS	3	3	965-587-03	Motorola	4015	1
Z7—Z10	IC, BCD Adder	0	8	965-587-63	National	4560	1
Z11—Z14	IC, Quad Comp.	4	4	965-587-64		74C85	1
Z15—Z18	IC, BCD Adder			965-587-68	National	4560	
Z19, Z20	IC, 4-2IN NOR	0	2	965-587-01	Motorola	4001	1
Z21, Z22	IC, 4-2IN NAND			965-587-02	Motorola	4011	
Z23	IC, Dual, CMOS	1	1	965-587-23	Fairchild	4013	1
Z24	IC, 4-Excl or CMOS	1	1	965-565-05	Fairchild	74C86	1
	Connector, Cable	1	1	973-390-00	Berg	65043-030	

ANALOG OUTPUT (OPTION 005A), ASSEMBLY 400-4410-XX

REF DES	DESCRIPTION	QTY	PIN	MFR	MFR'S PIN	REC SPARES
C1 C2	Cap, Tant, 2 2 @ 35V	5	916-220-04	Sprague	196D	
C3	Cap, Disc, 100pF @ 1KV	1	901-011-01	Sprague	5GA	
C4	Cap, 22 @ 35V	1	916-220-05	Sprague	196D	
C5	Cap Tant, 10 @ 35V	2	916-010-35	Sprague	196D	
C6	Cap Mica, 510pF	1	915-035-11	Sprague	DM15	
C7	Cap, Disc 005 @ 1KV	1	900-085-03	Sprague	5GA	
C8 C9	Cap, Tant, 2 2 @ 35V		916-220-04	Sprague	196D	
C10	Cap 68mF Film	1	919-068-00	Plessy		
C11	Cap, 1mF Film	1	919-100-00	Plessy		
C12	Cap, 22mF Film	1	919-022-00	Plessy		
C13, C14, C18 C21	Cap, Disc, 01 @ 50V	6	900-021-07	Sprague	5GA	
C15	Cap, Tant, 10 @ 35V		916-010-35	Sprague	196D	
C16	Cap Tant 2 2 @ 35V		916-220-04	Sprague	196D	
C17	Cap, Disc, 01 @ 500V		900-021-04	Sprague	5GA	
CR1-CR5	Diode, 1N914	6	961-091-40	Teledyne	1N4148	
CR6	Diode 6 4V	1	961-457-70	Siements	1N4577	
CR7	Diode, 1N914		961-091-40	Teledyne	1N4148	
J1	Connector, PC7M	1	973-380-00	Berg	65625-114	
Q1	Transistor, 2N3415	1	962-341-50	Motorola	NPNA98-5	1
R1 R2	Resistor, ¼W 5% 20K	2	942-202-03	Allen Bradley		
R3	Resistor, ¼W 5% 100	2	942-201-01	Allen Bradley		
R4	Resistor, ¼W 5% 180	1	942-201-81	Allen Bradley		
R5	Resistor, ¼W 5% 10K	1	942-201-03	Allen Bradley		
R6	Resistor, ¼W 5% 100	1	942-201-01	Allen Bradley		
R7	Resistor, ¼W 5% 6.8K	1	942-206-82	Allen Bradley		
R8, R9	Resistor, RN60C, 10K	2	920-410-02	Allen Bradley		
R10	Pot, 10K Cermet	1	960-451-11	Beckman	72XL	1
R11	Resistor, 1% 5.11K	1	920-475-01	Allen Bradley	RN60C	
R12	Resistor, ¼W 5% 330K	1	942-203-34	Allen Bradley		
R13, R14	Pot, 20K Cermet	2	960-012-11	Beckman	72XL	1
R15, R16	Resistor, 1% 150K	2	920-415-03	Allen Bradley	RN60C	
R17	Resistor, ¼W 5% 22M	1	942-202-26	Allen Bradley		
R18	Resistor, 100K Cermet	1	960-011-18	Beckman	72XL	1
R19	Resistor, ¼W 5% 100K	1	942-201-04	Allen Bradley		
R20	Resistor, 1% 100K	1	920-410-03	Allen Bradley	RN60C	
R21-R23	Resistor, ¼W 5% 51K	3	942-205-13	Allen Bradley		
R24	Resistor, ¼W 5% 150K	1	942-201-54	Allen Bradley		
R25	Resistor, ¼W 5% 3.3K	1	942-203-32	Allen Bradley		
R26	Resistor, ¼W 5% 1M	1	942-201-05			
R27, R28	Resistor, ¼W 5% 10	2	942-201-00			
R29	Resistor, ¼W 5% 1K	1	942-201-02			
T1	Transformer	1	967-020-10	Pulse	8270	1
TB1	Terminal Strip	1	973-010-32	Reed	6PCR02-002	
Z1	IC, Hex Inverter 74C04	2	965-587-05	RCA	4069	1
Z2	IC, Optical Isolator	1	965-570-00	HP	5082-4350	1
Z3	IC, Hex Inverter 74C04		965-587-05	RCA	4069	
Z4	IC, Mono-vibrator	1	965-587-72	Fairchild	4538	1
Z5	IC, Dual Op Amp	2	965-617-00	National	LM358	1
Z6-Z8	IC, 8-bit Register	3	965-587-65	RCA	4094	1
Z9	IC, 4-2 In NOR CMOS	1	965-587-01	Motorola	4001	1
Z10	IC, Quad Mux CMOS	1	965-587-06	RCA	4066	1
Z11-Z14	IC, Quad Comparator	4	965-587-64	RCA	74C85	1
Z15	IC, Binary Counter	1	965-587-66	RCA	74C161	1
Z16-Z18	IC, BCD Counter	3	965-587-67	RCA	74C160	1
Z19	IC, Dual Op Amp		965-617-00	National	LM358	
	Connector, Cable	1	973-390-00	Berg	65043-030	

SERIES 400, BASIC INDICATOR HARDWARE

Description	Quantity	Part Number
Chassis, Die-cast	1	400-2010-05
Label, Input Terminals	1	400-2246-01
Label, Input Power (115 VAC)	1	400-2247-00
Label, Input Power (230 VAC)	1	400-2248-00
Rear Cover	1	400-2470-03
Bracket, Panel Mounting	1	400-2480-02
Label, Data Output Cover	1	400-2630-00
Front Panel, Red Plexiglas	1	400-2760-00
Label, Serial Tag	1	400-2795-00
Display Board to Case:		
Screw, PHMS 4-40 x ¼	2	980-440-025
Washer, #4 Split Lock	2	986-200-04
Rear Grounding Screw:		
Screw, Panhd PH 6-32 x 5/8	1	980-632-063
Washer, #6 Star	1	986-200-06
Rear Cover to Case:		
Screw, Panhd PH 8-32 x 3/8	1	980-832-038
Washer, #8 Split Lock	1	986-200-08
Panel Mtg. Bracket to Case:		
Screw, Panhd PH 8-32 x ½	2	980-032-050
Plexiglas to Case:		
Screw, Fillister 4-40 x 3/8	2	982-4400-038
Grommet, Nyl ¾, Rear Cover	1	991-056-25
Input Wires		
Plug, Bench Mount Holes	2	991-057-02
Power Cord	1	993-200-07

Power Pack 406/407, Hardware

Description	Quantity	Part Number
Model 406 Front Panel Overlay	1	406-2040-01
Model 407 Front Panel Overlay	1	407-2040-01
Chassis, Die-cast, Battery Pk.	1	406-2010-05
Label, Serial Tag	1	400-2795-00
Case, Power Pack	1	407-2000-01
Rear Cover	1	407-2010-02
Label, Rear Cover Instruction	1	407-2070-01
Rear Cover to Case:		
Screw, Panhd PH 8-32 x 3/8	4	980-832-038
Washer, #8 Flat	4	986-100-08
Washer, #8 Split Lock	4	986-200-08
Handle, Power Pack Case	1	991-050-08
Handle to Case:		
Screw, Flathd PH 8-32 x 1/2	2	981-832-050
Foot, Adhesive Backed, Black	8	991-055-04
Front Panel, Battery Pack	1	407-2020-01
Battery Clamp	1	407-2030-01
Connector, Battery Plug	1	973-070-10
Binding Post, white	1	973-301-00
Binding Post, red	1	973-301-01
Battery Clamp to Panel:		
Screw, Panhd PH 6-32 x 3/8	2	980-632-038
Washer, #6 Star	2	986-400-06
Battery Clamp to PCB:		
Screw, Flathd PH 6-32 x 3/8	4	981-632-038
Standoff, 1-1/2 x 6-32	2	991-020-77
Nut, Speed Nut 6-32	4	991-040-64
Voltage Regulator Heatsink:		
Heatsink	1	991-008-00
Heatsink Clip	1	991-040-49
Nut, #6 Hex	1	984-100-632
Knob (407)	2	991-050-05
I/O Cable, Power Pack	1	993-300-06

MANUAL ADDENDUM

Application of the Series 400 digital indicators is broadened with the availability of a new PMOS LSI chip (K7503, order code LSID). The LSI chip, in conjunction with new analog programming modules, provides seven additional ranges as described in Table 1 below:

TABLE 1

RANGE DESIGNATOR	LSI CHIP CODE	TYPE OF INPUT	RANGE	400A/402A		410A/412A	
				RESOLUTION	ACCURACY**	RESOLUTION	ACCURACY**
0C	D	Tungsten 5% Rhenium - Tungsten 26% Rhenium Thermocouple	-8° to +2372°C	1°C	1.7°C	0.1°C	0.8°C
0N	D	Nicrosil - Nisil Thermocouple	32° to 2400°F 0° to 1315°C	1°F 1°C	1.5°F 1.0°C	0.1°F 0.1°C	0.6°F 0.4°C
CG	D	Chromel - Gold .07% At. Iron Thermocouple	0° to 280 K	1 K	1.0 K	0.1 K	0.3 K
P7	D	PT-100Ω, 4 wire α .00392 Platinum RTD, °C	-30° to +143°C	0.1°C	0.14°C	0.01°C	0.073°C
P8	D	PT-100Ω, 4 wire α .00392 Platinum RTD, °F	-50° to +262°F	0.1°F	0.27°F	0.01°F	0.141°F
N3	D	Ni-120Ω, 3 wire Nickel RTD†	-130° to +612°F -94° to +322°C	1°F 1°C	1.0°F 1.0°C	0.1°F 0.1°C	0.4°F 0.2°C
N4	D	Ni-120Ω, 4 wire Nickel RTD†	-138° to +612°F -94° to +322°C	1°F 1°C	1.0°F 1.0°C	0.1°F 0.1°C	0.4°F 0.2°C

*Not an ANSI symbol

**Include errors due to linearization, A/D conversion, internal instrument noise, and ± 10% line voltage variation at 25 ± 3°C (77 ± 5°F) for 24 hours without zero or scale adjustment. All contributing errors are added together to produce worst case instrument accuracy.

†Linearization curve based upon Minco Table 7-120.

The calibration values and display readings for the new ranges are given in Table 2 below:

TABLE 2

RANGE	SENSOR TYPE	INPUT	ADJUST	READ	INPUT	ADJUST	READ	INPUT	ADJUST	READ
C	Tungsten 5% Rhenium - Tungsten 26% Rhenium	0mV	Zero	0°C	37.107mV	+Span	2320°C	____	____	____
N	Nicrosil - Nisil	0mV 0mV	Zero Zero	32°C 0°C	46.048mV 46.048mV	+Span +Span	2300°F 1260°C	____ ____	____ ____	____ ____
CG	Chromel - Gold .07% At. Iron	-5.256mV	Zero	5 K	0.041mV	+Span	275 K	____	____	____
P7	Platinum RTD R_O=100Ω 4 Wire α=.00392	100Ω	Zero	0°C	154.62Ω	+Span	140°C	90.00Ω	-Span	-25°C
P8	Platinum RTD R_O=100Ω 4 Wire α=.00392	100Ω	Zero	32°C	148.67Ω	+Span	256°F	82.62Ω	-Span	-46°F
N3	Nickel RTD R_O=120Ω 3 Wire	120Ω 120Ω	Zero Zero	32°F 0°C	471.20Ω 471.20Ω	+Span +Span	608°F 320°C	66.60Ω 66.60Ω	-Span -Span	-112°F -80°C
N4	Nickel RTD R_O=120Ω 4 Wire	120Ω 120Ω	Zero Zero	32°F 0°C	471.20Ω 471.20Ω	+Span +Span	608°F 320°C	66.60Ω 66.60Ω	-Span -Span	-112°F -80°C

The K7503 LSI chip also supports existing Platinum and Copper RTD, Thermistor, and linear current and voltage ranges with the use of the appropriate programming module. Calibration is described in Section 4 of the manual.

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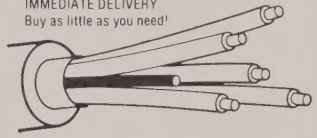

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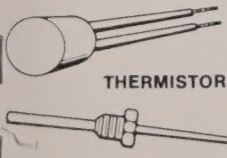

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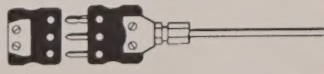

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